

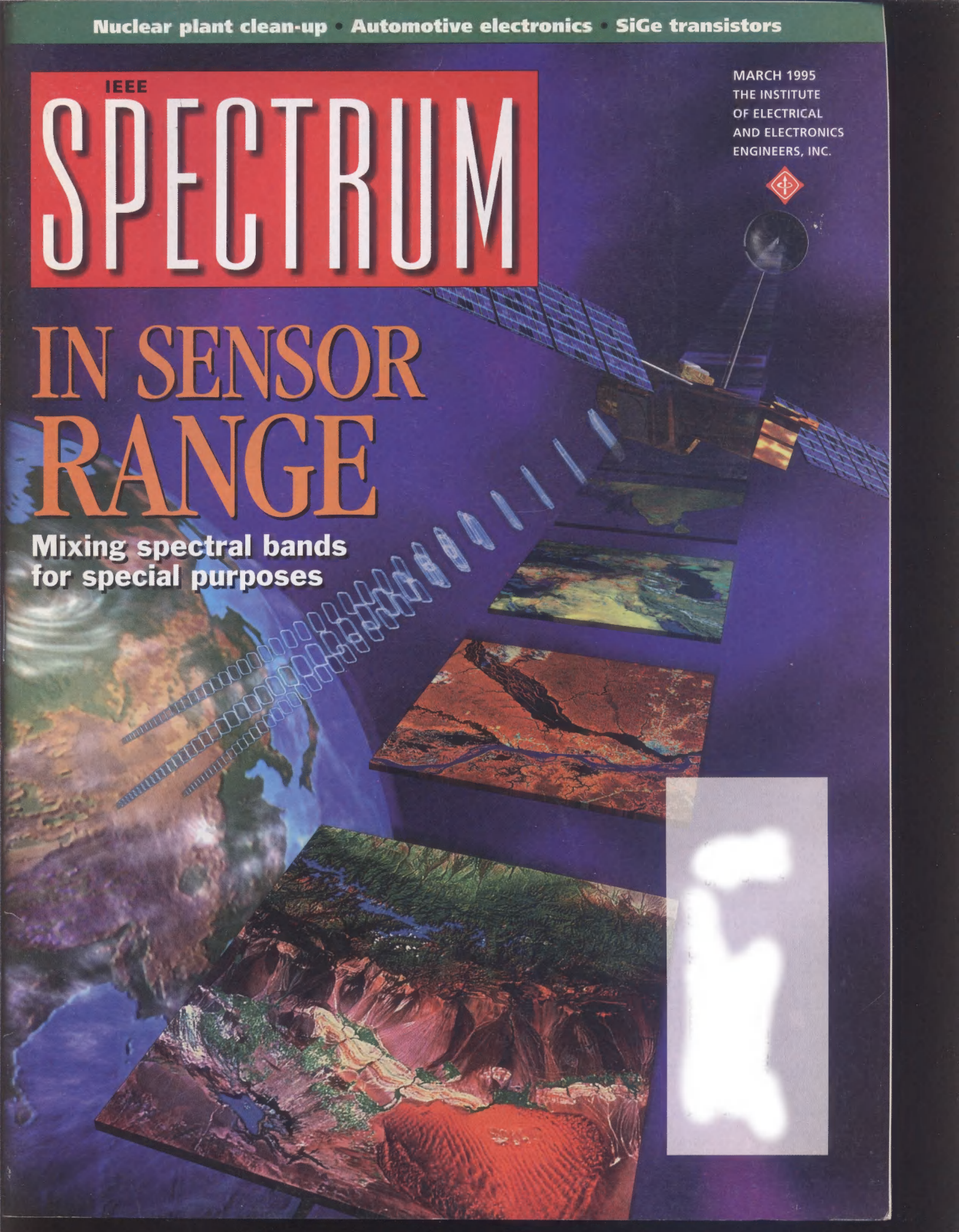
IEEE

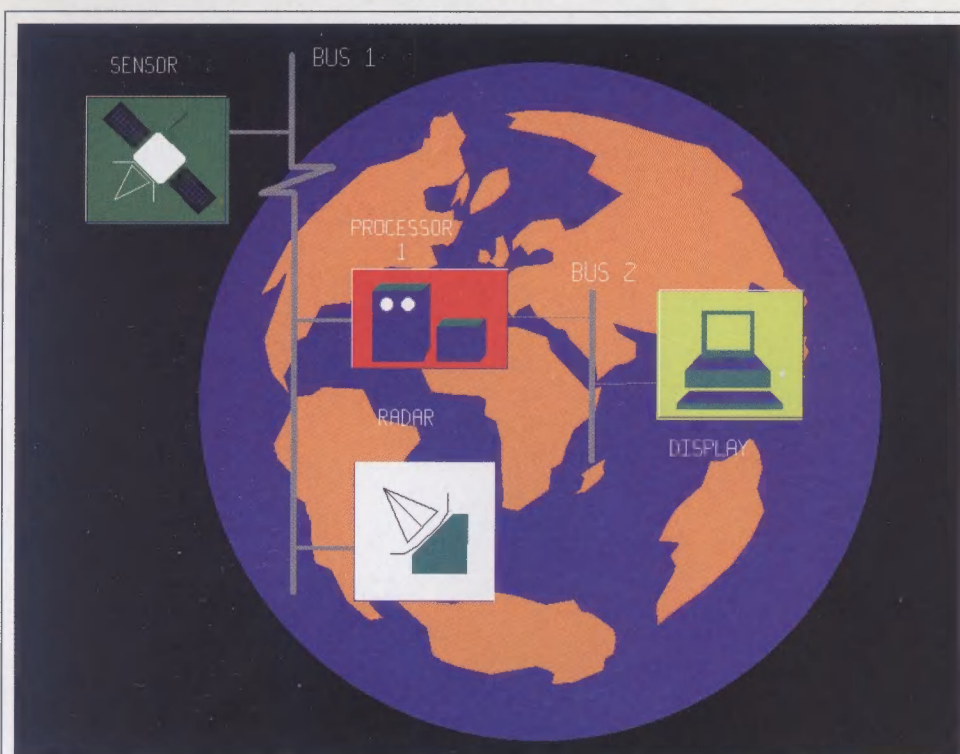
SPECTRUM

IN SENSOR RANGE

Mixing spectral bands
for special purposes

MARCH 1995
THE INSTITUTE
OF ELECTRICAL
AND ELECTRONICS
ENGINEERS, INC.





Realistic simulation of your network or embedded computer system—quick results, no programming.

NETWORK II.5 now predicts performance of computer-communication systems

Free trial and, if you act now, free training

NETWORK II.5 uses simulation to predict your network performance. You simply describe your network and workload.

Animated simulation follows immediately—no programming delays.

Easy-to-understand results

You get an animated picture of your network. System bottlenecks and changing levels of utilization are apparent.

Seeing your network animated increases everyone's understanding of its operation and builds confidence in your results.

Your reports show response times, messages delivered, messages lost, device utilization, and queueing statistics.

Computers with NETWORK II.5

NETWORK II.5 is available for most PC's, Workstations, and Mainframes.

Your network simulated

You can analyze embedded or distributed computer systems, or other computer-communication networks. Industry standard protocols such as FDDI and IEEE Standard 802.X are built-in. Others can be modeled.

You can easily study the effect of changing network parameters or even network protocols.

You can simulate some portions of the network at a detailed level and others at a coarser level.

Free trial information

The free trial contains everything you need to try NETWORK II.5® on your computer. For a limited time we also include free training—**no cost, no obligation.**

Call us in the U.S. at (619) 457-9681. In the Wash., DC Area, call us at (703) 875-2900. In Europe, call us in The Netherlands, on +31 43 670780. In the UK, call us on +44 (0)1276 671 671.

Free trial offer

☐ Yes, I want to see how NETWORK II.5 quickly answers network performance questions.

Limited offer—Act now for free training.

Name

Organization

Address

Telephone Fax

Computer O/S

☐ Send details on your University Offer.

Worldwide:
CACI Products Company
3333 North Torrey Pines Ct.
La Jolla, California 92037
Call (619) 457-9681
Fax (619) 457-1184

Wash., DC Area:
CACI Products Company
1600 Wilson Blvd.
Arlington, VA 22209
Call (703) 875-2900
Fax (703) 875-2904

Europe:
CACI Products Division
MECC Business Center
G. Martino Laan 85, 8th Floor
6229GS Maastricht, The Netherlands
Call +31 43 670780 Fax +31 43 670200

UK:
CACI Products Division
Coliseum Business Centre
Watchmoor Park, Riverside Way
Camberley, Surrey GU15 3YL, UK
Call +44 (0)1276 671 671 Fax +44 (0)1276 670 677

Mie spec

CACI Products Company

NETWORK II.5 is a registered trademark of CACI Products Company. ©1995

newslog

JAN 9. NEC Corp., Tokyo, said it would produce IBM-compatible PCs for China with Shanghai-based **Changiang Computer Union Corp.** The joint venture would make NEC the first Japanese company to manufacture PCs in China.

JAN 10. British Telecommunications and **Viag**, one of Germany's biggest industrial groups, announced plans to form a \$980 million joint venture to break into the German telecommunications market.

JAN 11. The Justice Department said it had formally notified **Airtouch Communications**, San Francisco, that as a former unit of the Pacific Telesis Group, it was still subject to the antitrust decree that broke up the Bell System in 1984. But the department said that Airtouch could continue to bundle cellular and long-distance phone services in a package until the issue is decided by district judge Harold H. Greene, who oversees the Bell decree.

JAN 11. Intel Corp., Santa Clara, Calif., and **Advanced Micro Devices Inc.**, Sunnyvale, Calif., announced they had ended their seven-year legal battle over whether Advanced Micro had the right to make copies of Intel's microprocessor chip. The settlement calls for AMD to pay Intel US \$58 million for past damages and Intel to pay AMD \$18 million for breach of contract.

JAN 12. The Federal Communications Commission announced it had allocated a portion of the airwaves to digital audio radio, a new class of service that would bounce compact-disk-quality programming off satellites directly to listeners' radios. The National Association of Broadcasters said it would try to block the service.

JAN 13. Sandia National Laboratories, Albuquerque,

N.M., said that by hooking up two of **Intel Corp.**'s Paragon supercomputers to each other, researchers had nearly doubled the world record in computing speed, clocking in at 281 gigaflops and leapfrogging Fujitsu Ltd.'s 170.4 gigaflops. Linked, the two Intel machines had 6786 processors working in parallel.

JAN 16. GTE Corp., Stanford, Conn., said a Federal court had ruled that the company might re-enter television services it had to abandon in the early '80s when cable TV laws went into effect. The decision gives GTE Telephone Operations the right to provide video programming to GTE local phone customers, some 17 million nationwide.

JAN 17. A Federal appeals court ordered district judge **Judge David N. Edelstein**, who has overseen the Justice Department's antitrust settlement with **IBM Corp.** for almost 40 years, to remove himself from the case, saying he does not appear impartial. IBM has repeatedly asked the judge, without success, to lift a 1956 consent decree that restricted the company's operations, saying the settlement was obsolete.

JAN 19. The Electronic Industries Association of Japan said that most semiconductor production in the Kobe region continued to operate normally after the **Jan. 17 earthquake**, but that officials were still checking liquid-crystal display production equipment at Toshiba and Sharp facilities, while Hoshiden's Kobe factory had shut down its operations.

JAN 24. Japan's Matsushita Electric Industrial Co. said that it had endorsed the digital videodisk system developed by **Toshiba Corp.** because its images were of higher quality than those of the rival system

developed by Sony Corp. and Philips Electronics NV.

JAN 24. CERN, the European Laboratory for Particle Physics near Geneva, Switzerland, said it was handing over its development of the World Wide Web to **Inria**, France's national computing research institute. Inria will work with the World Wide Web Consortium at the Massachusetts Institute of Technology in Cambridge.

JAN 24. The U.S. Food and Drug Administration and **Telectronics Pacing Systems**, Englewood, Colo., said they had advised 42 000 patients with certain pacemakers to be X-rayed for possibly fractured wires. Models 330-801 and 329-701 have been linked to two deaths and several injuries; model 330-812 was distributed outside the United States.

JAN 24. Inmarsat, the London-based satellite communications organization, said it had raised \$1.4 billion from 38 telephone companies around the world to launch a global satellite system for hand-held phones by 1999.

JAN 25. Nynex Corp. said it had opened its New York market to local telephone competition by slashing what it charges rival **MFS Communications Corp.**, Omaha, Neb., for using its network, and had agreed to allow Nynex customers who switch to MFS to keep their phone numbers without charging them extra. The groundbreaking pact may be copied by other regional Bell companies.

JAN 26. Germany's Veba AG announced it would take a 10 percent stake in **Cable & Wireless PLC**, London. The partners are to create two joint ventures: one to focus on the German telecom market and one to obtain local partners in European markets.

JAN 26. China Great Wall Industrial Corp. said a Chinese Long March rocket carrying the U.S.-made Apstar 2 telecommunications satellite exploded over its launch pad in Sichuan province. Falling debris killed six people and injured 23. Apstar 2, built by **Hughes Space and Communications Co.**, Los Angeles, was to have provided TV and telecom links across Asia, Europe, and Africa.

JAN 30. Nippon Telegraph and Telephone Corp. said it would invest \$123 million in **Smart Communications Inc.**, Manila, one of seven new common carriers in the Philippines. The deal will allow Smart to supply local phone service in the country's northern part.

JAN 31. AT&T Corp. and **VLSI Technology Inc.**, San Jose, Calif., said they would produce low-cost encoding chips more rugged than the Clipper chip proposed by the Clinton administration to ensure the privacy of voice and data communications. AT&T is providing the security software—a triple-strength version of the data encryption standard—while VLSI will produce the chips.

FEB 2. NASA said the **U.S. space shuttle Discovery** had rendezvoused with the **Russian space station Mir**, getting as close as 12 meters. The mission was a test flight for at least seven dockings of the U.S. space shuttle Atlantis and Mir through 1997.

Preview

MAR 28–31. The Fifth Conference on Computers, Freedom, and Privacy is to take place in Burlingame, Calif. Subjects to be spotlighted will include the responsibility of electronic speech and copyright protection. For more information, call 415-548-9673.

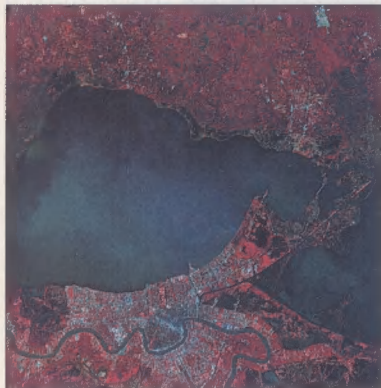
SALLY CAHUR

contents

MARCH 1995

VOLUME 32

NUMBER 3



MITI/NASDA/EOSAT

special report

24 Harvesting remote-sensing data

BY TRUDY E. BELL

With the advent of powerful workstations and affordable software, data from remote-sensing satellites are at last being winnowed and sifted for special-purpose information, sometimes in combination with other inputs. Still more data will become available with the launch, over the next two years, of new commercial satellites with high-resolution remote sensing.



CONSOLIDATED
EDISON CO. OF
NEW YORK, INC.

power

32 Slowing the aging of nuclear power plants

BY STEPHEN A. TROVATO, JOHN O. PARRY,
& JAMES M. BURGER

For the first time, the full primary system of an operational nuclear power plant is being decontaminated—to lower its radioactivity and hence its maintenance costs. Productivity should rise, too.

applications

37 The electronic motorist

BY RONALD K. JURGEN

The shortcomings of the human driver are getting help from emerging technologies in the guise of navigation systems, engine immobilizers, night vision assistance, and fuzzy logic.



OLDSMOBILE DIV., GENERAL MOTORS CORP.

departments

- 1 Newslog
- 6 Forum
- 10 Books

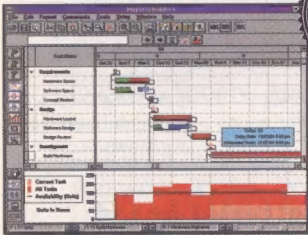
Cover illustration: Douglas Chezem.
Photographs courtesy of Earth
Observation Satellite Co. (EOSAT)

IEEE SPECTRUM (ISSN 0018-9235) is published monthly by The Institute of Electrical and Electronics Engineers, Inc. All rights reserved. © 1995 by The Institute of Electrical and Electronics Engineers, Inc., 345 East 47th St., New York, NY 10017, U.S.A. Canadian Post International Publications Mail (Canadian Distribution) Sales Agreement No. 0338087. Cable address: ITRIPLLE. Telex: 236-411. Fax: 212-705-7453. INTERNET: m.slovick@ieee.org ANNUAL SUBSCRIPTIONS. IEEE Members: \$11 included in dues. Nonmembers: \$36. Libraries/institutions: \$157. SINGLE COPIES. Members: \$8 first copy. Nonmembers: \$16. MICROFICHE SUBSCRIPTIONS. Members: \$16. Nonmembers and libraries: \$157. POSTMASTER: Please send address changes to IEEE Spectrum, c/o Coding Department, IEEE Service Center, 445 Hoes Lane, Box 1331, Piscataway, NJ 08855. Second Class postage paid at New York, NY, and additional mailing offices. Canadian GST #125634188. Printed at 8649 Hacks Cross Rd., Olive Branch, MS 38654, U.S.A. IEEE Spectrum is a member of the Audit Bureau of Circulations, the Magazine Publishers of America, and the Society of National Association Publications.



SOONER OR LATER, MS-PROJECT WILL CRAMP YOUR MANAGEMENT STYLE.

Only Project Scheduler 6
gives your projects the
ideal environment
to grow in.



Why be baited into software that starts out easy to use, but ultimately compromises your ability to efficiently plan, track, evaluate and report all of your project management data?



**Version 1.5
Now Shipping**

Choose Project Scheduler 6® for Windows™ and get the tools and professional project management insight to effectively handle all of the changing deadlines, schedule crunches and resource allocation problems that happen in the real world.

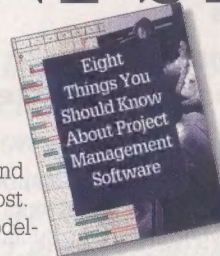
"Aimed at users who don't [necessarily] manage projects full-time, but want a product that won't run out of steam, [Project Scheduler 6] surpasses Microsoft Project and CA SuperProject – in addition to challenging many high end packages," wrote *InfoWorld*†

So whether you're managing one or one hundred projects, all of your activities are streamlined with a single, unlimited resource pool, task and resource calendars,

user-configurable spreadsheets, plus interactive graphics and icons for quick access to functions and views you use the most.

Sophisticated modeling features like the Advanced Resource Tracking Spreadsheet (ARTS)™, let you uniquely evaluate resource costs and usage on a period-by-period basis. Evaluating multiple "what-if" scenarios is a breeze with Project Scheduler's ability to do multiple undo/redos. And our built-in object-oriented report writer offers outstanding layout versatility.

You can even selectively share project data with other ODBC-



Before you make a project management software decision, call for this free executive summary.

Call 1-800-533-9876

compliant applications. Now in its second generation, Project Scheduler's Open Database Connectivity helps build greater data reporting efficiency and controls throughout the enterprise.

Don't get caught short by the lure of software that won't completely support your projects downstream. Get Scitor on the line, and try Project Scheduler 6 for Windows today.

Scitor Corporation

© 1994 Scitor Corporation, 393 Vintage Park Drive, Suite 140, Foster City, CA 94404. Tel. 415-570-7700. Internet: sales@scitor.com. In France, call (1) 43 29 44 37. In Germany, call 0 69-6 66 80 25. In the United Kingdom, call 0384-392121. In Australia, call (02) 956-7800. In South Africa, call (011) 886-5283. Project Scheduler 6 is a registered trademark, and ARTS and the Scitor name are trademarks of Scitor Corporation. InfoWorld, January 3, 1994. Microsoft Project and Windows are trademarks of Microsoft Corp. CA SuperProject is a trademark of Computer Associates. No fish were subjected to undue cruelty during the making of this ad.

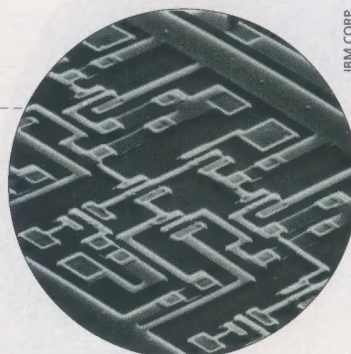
contents

solid state

49 The SiGe bipolar transistor

BY JOHN D. CRESSLER

Germanium atoms take silicon to speeds it could not reach before. The proof is the ring oscillator at right. Thanks to refined techniques of material growth, circuits using these devices have made their way to market and bode especially well for wireless communications.



IBM CORP.

profile

56 Wilson Greatbatch

BY JOHN A. ADAM

Millions of patients can thank this engineer literally from the bottom of their hearts because in 1958 he invented an implantable cardiac pacemaker, working in a barn outside Buffalo, N.Y. He has gone on improving it ever since, amid his countless other activities.



ROBERT LEWIS

careers

62 The in-house springboard to success

BY JOHN A. HOSCHETTE

Your company's help-wanted notices can point the way to a better job right under your nose. Equally important is keeping close tabs on what's happening at the competition.



PAUL ANDERSON

departments

16 Calendar

22 Reflections

19 EV watch

69 EEs' tools & toys

20 Program notes

84 Coming in Spectrum

SPECTRUM

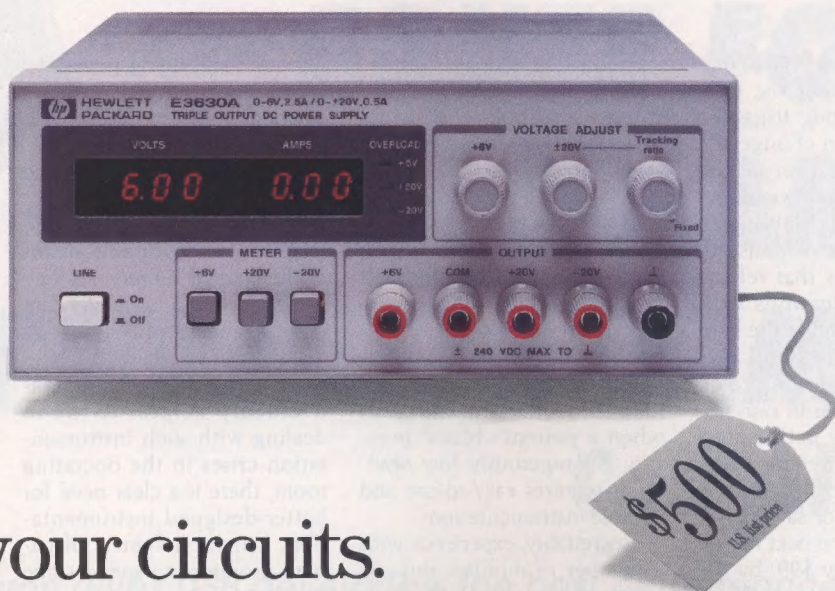
staff

EDITOR and ASSOCIATE PUBLISHER: Murray Slovick
 MANAGING EDITOR: Alfred Rosenblatt
 SENIOR TECHNICAL EDITOR: Gadi Kaplan
 SENIOR EDITORS: Trudy E. Bell, Richard Comerford, Tekla S. Perry, Michael J. Riezenman
 SENIOR ASSOCIATE EDITOR: John A. Adam
 ASSOCIATE EDITOR: Linda Geppert
 HEADQUARTERS: New York City, 212-705-7555 BUREAUS: WASHINGTON, D.C., John A. Adam, 202-544-3790; SAN FRANCISCO, Tekla S. Perry, 415-328-7570
 CORRESPONDENTS: John Blau (Düsseldorf); Chris Brown (Taipei); Peter Gwynne (Belgium); Robert Ingersoll (Bonn); John Mason (Barcelona); Roger Milne (London); Kim Nak-Hieon (Seoul); Roger Schreffler (Tokyo); Bradford Smith (Paris); Axel de Tristan (Rio de Janeiro); Christopher Trump (Toronto);
 CHIEF COPY EDITOR: Margaret Eastman
 COPY EDITOR: Sally Cahur
 EDITORIAL RESEARCHER: Alan Gardner
 CONTRIBUTING EDITORS: Robert Braham, Dave Dooling, John R. Hines, Egil Juliussen, Ronald K. Jorgen, Bennett Z. Kobb, Gerry Khermouch, Sue J. Lowe, Kevin Self, Michael F. Wolff
 EDITORIAL SUPPORT SERVICES: Rita Holland (Manager)
 EDITORIAL ASSISTANTS: Ramona Foster, Desiree Noel
 ART DIRECTOR: Mark Montgomery
 ASSOCIATE PUBLISHER, OPERATIONS: Fran Zappulla
 BUSINESS MANAGER: Robert T. Ross
 PRODUCTION: Alan B. Schafer (Director)
 ADVERTISING PRODUCTION: Martin Barbieri (Manager)
 EDITORIAL PRODUCTION:
 Roy Carubia (Editorial Production Manager)
 Paul Miller (Electronic Layout Artist)
 Morris Khan (Technical Graphic Artist)
 ASSOCIATE PUBLISHER: William R. Saunders
 ADVERTISING MANAGER: Michael Triunfo
 ADMINISTRATIVE ASSISTANT: Christine Demchak
 MAIL LIST SALES: Shelly Newman (Manager)
 Lizette Graciani
 SALES PROMOTION MANAGER: Eric Sonntag
 ASSOCIATE PROMOTION MANAGER: Theresa Fitzpatrick
 ADMINISTRATIVE ASSISTANT: Nancy T. Hantman
 EDITOR EMERITUS: Donald Christiansen
 EDITORS BY E-MAIL:
 John A. Adam j.adam@ieee.org
 Trudy E. Bell t.bell@ieee.org
 Richard Comerford r.comerford@ieee.org
 Linda Geppert l.geppert@ieee.org
 Gadi Kaplan g.kaplan@ieee.org
 Tekla S. Perry t.perry@ieee.org
 Michael J. Riezenman m.riezenman@ieee.org
 Alfred Rosenblatt a.rosenblatt@ieee.org
 Murray Slovick m.slovick@ieee.org

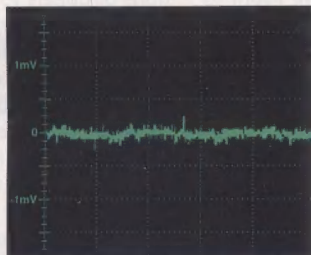
editorial board

CHAIRMAN: Murray Slovick
 Robert A. Bell, Diana J. Bendz, Barbara A. Chappell, Peter Cochrane, Fumio Harashima, Karl Hess, Narain G. Hingorani, O'Dean P. Judd, Robert E. Kahn, Charles K. Kao, Yoichi Kaya, David J. Kuck, Raymond S. Larsen, Ruby B. Lee, Ted G. Lewis, Wayne C. Luplow, Colin Maunder, Knut Merten, Suzanne R. Nagel, Michael Pecht, Shari L. Pfeleger, Larry Stern, Stephen H. Unger, Andrew Viterbi, Victor Wouk

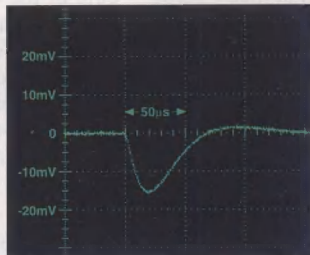
Finally, a power supply that's easy on your budget.



And your circuits.



Low noise, like that in the 20V output above, means this supply won't be a source of unexpected errors.



After a load change (50% to 100%, for example), fast transient response guarantees a quick return to the set voltage.



Tight 0.01% regulation means stable output when the load or line varies.

This supply makes it easy to stay within budget, without making compromises.

Want to avoid compromises? Get the HP E3630A, and enjoy low noise, tight regulation, and quick transient response — performance found in no other low-cost supply. And with overvoltage, overcurrent and short-circuit protection, you won't worry about circuit damage.

This supply combines our years of experience in high-performance power supply design with the latest techniques in efficient manufacturing. Close attention to quality makes it easy to offer a three-year warranty, too.

With this family, it's easy to find a perfect match.

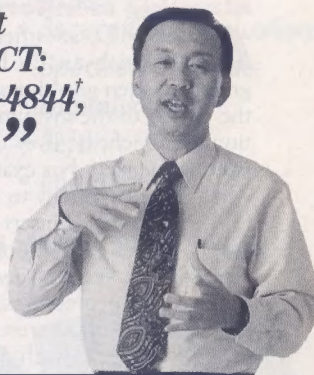
The HP E3630A is part of the HP E3600-series, all of which offer excellent price value (starting at \$300*) without cutting corners. A variety of output ranges and capabilities means you'll find one that fits your specific application.

HP DIRECT: The easy way to get the answers you need.

One call to HP DIRECT will connect you to an experienced engineer ready to help you compare specs and make sure you get the right power supply for your needs.

Circle No. 7

“Isn't it time you had clean, reliable power on your bench? Call me at HP DIRECT: 1-800-452-4844, Ext. 9207.”



* U.S. list price.

There is a better way.

**hp HEWLETT®
PACKARD**

forum

Bugged by software

The furor about the Pentium chip bug triggered in me an eruption of anger—a long-smoldering anger toward commercial software vendors.

Why does the public not exhibit the same response to software vendors that release expensive applications with bugs at least as bad as the Pentium bug? I understand that zero-defect software is probably not achievable in our lifetime, but I really get steamed when a software vendor either tries to explain why a bug is not really a bug or says that it will be fixed in the next release (available for only \$99, by the way, and no promises). There are some vendors that will go out of their way to help with problems, while others take the attitude that, "Yes, it does seem to do that.... Isn't that interesting."

Some of the bugs I have encountered from name brand vendors are so obvious that I do not see how the software could have gotten through beta testing. I could go on with numerous examples, but I hope I am not the only soul out here who would like to demand more from software vendors.

Bill Waggener

73240.1410@compuserve.com

Alarming monitors

As an M.D. anesthesiologist with an EE background, I often give thought to the design of the instrumentation on which the lives of my patients depend. For example, when I put a patient to sleep for heart surgery, I insert invasive and noninvasive monitoring lines to keep an eye on cardiac filling pressures, cardiac output pressures, and other parameters such as the electrical pacing and conduction properties of the heart.

Usually five or more signals and derived parameters (such as heart rate or mean blood pressure) are displayed in real time on a high-resolution mon-

itor. These data are just as important to me as flight-related data are to an aircraft pilot, and form the basis for deciding, say, which drugs I administer to get out of clinical crises.

For instance, low blood pressure may be due to low cardiac output (flow) through normal-resistance blood vessels, or normal flow through low-resistance vessels. Determining which situation exists (and thus what drugs to give) when a patient's blood pressure is dangerously low obviously requires easy-to-use and reliable instrumentation.

Regrettably, experience with a number of monitor designs has taught me that much needs to be done to make operating room monitors trustworthy and ergonomically sensible. Some examples of monitoring problems, from my own or my clinical associates' experience, illustrate the point.

I know of two monitor designs that occasionally reboot for no apparent reason in the middle of surgery (possibly due to EMI from the electrosurgical apparatus, or even nearby cellular phones, but possibly also software-related). During the reboot, the patient is at increased risk. The situation is especially frustrating when the pressure-signal-related zero offset information is lost on reboot and the pressure transducers must all be rezeroed.

One monitor I know of on occasion slips into demo mode, displaying totally synthetic data, with a note to that effect in the corner of the display. When this happened to one clinician while transporting a patient, he was unable to quit the demo mode because he did not know the required service password!

The monitoring system I use most frequently will often announce an "asystole" (cardiac arrest) alarm when the electrocardiogram signal falls below a certain amplitude. The fact that normal cardiac pres-

ures are still being generated is ignored by the alarm management software, resulting in an obviously wrong diagnosis.

This kind of haphazard and ill-conceived alarm arrangement is why many of my colleagues globally disable alarms at the start of surgery, so they can concentrate on taking care of the patient rather than follow up countless false alarms.

While my EE background is decidedly helpful to me in dealing with such instrumentation crises in the operating room, there is a clear need for better-designed instrumentation. I invite designers of patient monitors to spend some time in the operating room to appreciate how much needs to be done. At the very least, they should be interviewing users to understand the many problems with existing monitoring systems.

D. John Doyle
Toronto

Engineers Without Borders

In response to Scott Bugno's inquiry about volunteer organizations of engineers [October 1994, p. 4], here is some information about Ingeniería Sin Fronteras (ISF).

Our members are engineers, engineering students, and others who work in technical areas. In working for a juster world, we offer our knowledge, experience, and free time to less favored communities.

ISF is a nonpolitical organization. In Spain, it is five years old and has groups in more than 10 cities, always based on a university. There is a similar organization in France.

Our principal objectives are development projects, which are nonviolent and respectful of nature and of human rights; and programs to sensitize society through meetings, publications, and social movements.

For more information about ISF, the contacts in Europe are Marta Viudez, External Rela-

tionships, ISF - Pais Vasco, jtaviblm@s835cc.bi.ehu.es; in Madrid, isf@etsit.upm.es; in France, isf@ensta.fr.

Marta Viudez
jtaviblm@s835cc.bi.ehu.es

Magnetic fields: malign or maligned?

The article "Today's view of magnetic fields" by Tekla S. Perry [December 1994, pp. 14-23] was a well-balanced presentation on the possible hazards. I expect, though, that the self-appointed debunkers among us will say that there is no problem, or that we cannot know if there is one without taking several decades and billions of dollars to study the situation. Some of the debunkers sound very like the executives for the cigarette industry. I hope that we can take a more reasoned approach.

There is another option besides reducing the fields or waiting for more data. That is to increase the power frequency from 60 Hz to some higher value—say, in the range of 120 to 600 Hz. In this day of power electronics, this is not as far-fetched as at first seems.

It would have been nice to mention two books: *Body Electric: Electromagnetism and the Foundation of Life*, by Robert O. Becker and Gary Selden (Morrow, New York, 1987), and *Cross-Currents: The Perils of Electropollution, the Promise of Electromedicine*, by Robert O. Becker (J. P. Tarcher, Los Angeles, 1990). Becker has had a long career as a research orthopedic surgeon and has learned a lot about electrical engineering. Reading his books certainly changed my paradigm.

The issue of behavioral changes needs more attention. It is possible that societal instances of poor judgment are at least partly due to the influence of magnetic fields. Dr. Becker explores some of these issues.

Gary L. Johnson
Manhattan, Kan.



DSP BRUTE FORCE HARDWARE & SOFTWARE TO TAME IT Call Alacron

Alacron gives DSP developers the best performance and easiest development for any operating system on both PC/ISA and VME bus systems.

Compare Our Performance Against C40-based Systems

	MFLOPS	1K Complex FFT	1K x 1K Real To Complex FFT	1K Real DOT Product
Alacron FT200 Series	100 MFLOPS	550µsec	782ms	20.4µsec
TI TMS320 C40 Series	50 MFLOPS	1,540µsec	2300ms	43.2µsec

*All performance numbers based on a single 50MHz processor

Alacron gives you high performance DSP hardware in an easy to use development environment. Our RT860 development and runtime environments support all major operating systems for both PC and VME platforms, including Solaris, Solaris X86, DOS, Windows, Lynx and Unix. And our highly optimized DSP vector libraries provide maximum performance through simple C or Fortran calls.

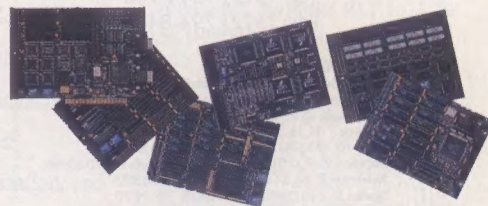
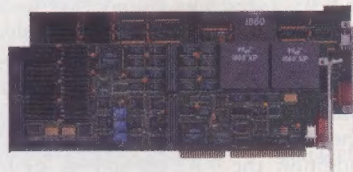
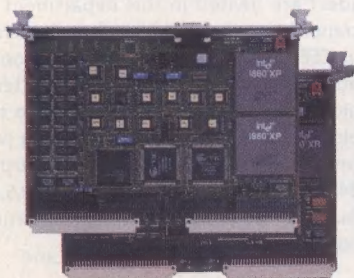
All Alacron systems can be customized with application specific daughtercards for both digital and analog data sources. If you are impressed by our single processor comparison, call and find out how our dual processor systems beat the competition's quad C40 systems.

Applications Include:

- Radar & Sonar
- Noise & Vibration Analysis
- Acoustics
- Secure Communications
- Spectrum Analysis
- Digital Radio
- Seismic
- Imaging

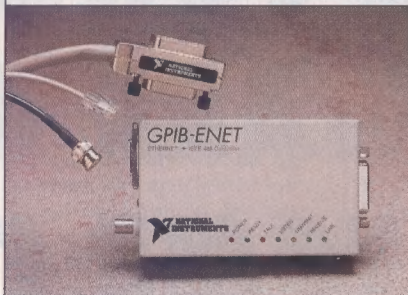
To find out more about our DSP performance systems:

Call (603) 891-2750



ALACRON

Distributed IEEE 488.2 Control over Ethernet



The GPIB-ENET—

TCP/IP—Ethernet to IEEE 488.2 Controller

- Control several GPIB systems from a single networked computer
- Share GPIB peripherals between several networked computers
- Includes NI-488.2™ driver software for Windows, Mac OS, HP-UX, or Sun Solaris
 - Removes TCP/IP Ethernet and GPIB complexity
 - Uses familiar NI-488.2 functions and development utilities
 - Is compatible with LabVIEW® and LabWindows®/CVI GPIB libraries

Call for your
**FREE GPIB
brochure**
(800) 433-3488



**NATIONAL
INSTRUMENTS™**
The Software is the Instrument®

6504 Bridge Point Parkway
Austin, TX 78730-5039
Tel: (512) 794-0100
Fax: (512) 794-8411

Branch Offices:

Australia 03 879 9422 • Austria 0662 435986
Belgium 02 757 00 20 • Canada 519 622 9310
Denmark 45 76 26 00 • Finland 90 527 2321
France 1 48 14 24 24 • Germany 089 741 31 30
Italy 02 48301892 • Japan 03 3788 1921
Mexico 95 800 010 0793 • Netherlands 03480 33466
Norway 32 84 84 00 • Singapore 2265886
Spain 91 640 0085 • Sweden 08 730 49 70
Switzerland 056 20 51 51 • Taiwan 02 377 1200
U.K. 01635 523545

© Copyright 1995 National Instruments Corporation. All rights reserved. Product and company names listed are trademarks or trade names of their respective companies.

forum

Continued from p. 6

I am shocked and embarrassed by the foolishness found in the article. Readers interested in this important subject are strongly advised to read the article "Fields of Fear" by Gary Taubes in the November 1994 issue of *The Atlantic*. There they will find a balanced and reasonable discussion of the gross inadequacies of epidemiological studies performed to date, the fear-mongering that has emerged from them, and the scarce financial resources being squandered on them.

Thomas B. Jones
Rochester, N.Y.

The following is excerpted from a letter to the editor of The Atlantic with permission from the writer, Louis Slesin, editor and publisher of Micro Wave News.—Ed.

When lecturing researchers and reporters on how to do their own work ("Fields of Fear"), Taubes should get his own facts right. That's hard to do when he avoids talking to many of the people he cites and quotes, preferring instead to cull quotations that suit his agenda.

In my case, Taubes just made it all up. For the record, I would never have said that the "bulk of EMF research is paid for by the military" because for most of the last decade the military has hardly funded any studies at all.

Allow me one of many possible examples of Taubes's selective reporting: his dismissal of an association between EMFs and breast cancer. Taubes makes it sound as if the only reason for the growing suspicion that EMFs may promote breast cancer is a report from the Johns Hopkins University (JHU) School of Hygiene and Public Health of two cases among male workers, which was later "played...up widely" by the press.

Let's look at the facts: The JHU group announced the findings in November 1989 at a Department of Energy Conference as part of a larger set of results showing an association between EMF work and many different types of cancer, particularly leukemia. These findings might have passed unnoticed because no reporter attended the conference other than me.

The JHU researchers did not rush into print. They did not publish their results until March 1991—16 months later—and only after two other groups, one in the United States and one in Norway, published similar findings.

In addition, the JHU researchers identified six cases of male breast cancer, not two as Taubes reported. The other four

cases occurred outside the study period and so were excluded from the statistical analysis, but this unexpectedly large cluster of cases of such a rare disease piqued their interest.

At this writing, five research teams have reported an association between male breast cancer and EMFs. And two of these groups later reported a female breast cancer-EMF link. Not every epidemiological study has found this link, but the human studies are supported by a series of impressive animal and cellular experiments, as well as mechanistic studies.

Is there a mislabeled graph on p. 21 of "Today's view of magnetic fields"? Is a typical room at home really 30 ft by 40 ft?

Doug S. Phillips
Calgary, Canada

It is if you want to have spots in the room not affected by fields.—Ed.

(Additional letters written in response to Spectrum's article on EMF will be published in the coming issue.—Ed.)

Corrections

On the second line of the second column in the Viewpoint on p. 32 of the January issue, the T1 speed ought to have been 1.544 Mb/s.

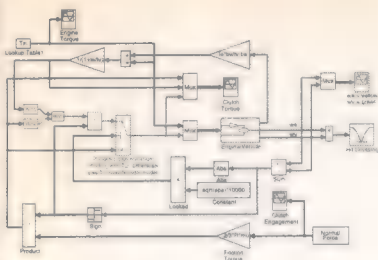
On the 14th line of the first paragraph in the first column on p. 37, the on-chip unified secondary cache memory should have been 94KB.

In the graph on p. 58, the four lowest values of average electricity rates in dollars per kilowatt-hour should have been given as 0.02, 0.04, 0.06, and 0.08.

In the box on p. 90, the e-mail address for the Transactions Department should have been given as trans@ep.ieee.org.

The *Proceedings* of the 16th Annual Conference of the IEEE Engineering in Medicine and Biology Society, which was held Nov. 3–6, 1994 [January 1995, p. 89], is available both on a CD ROM and in printed form. The disk is obtainable from Meeting Management, 2603 Main St., Suite 690, Irvine, CA 92714; 714-752-8205. The printed two-volume set may be obtained from the IEEE Service Center, Box 1331, Piscataway, NJ 08855; 800-678-IEEE.—Ed.

Readers are invited in this department to comment on material previously published in *IEEE Spectrum*, on the policies and operations of the IEEE, and on matters of technical, economic, or social interest to the electrical and electronics engineering profession. Contact: Forum, *IEEE Spectrum*, 345 E. 47th St., New York, NY 10017, U.S.A.; fax, 212-705-7453. The e-mail (Internet) address is n.hantman@ieee.org.



☒ Yes, send me a free SIMULINK® technical brochure.

I am currently a MATLAB® user: ☐ Yes ☐ No

Please send me information on the following products:

☐ MATLAB ☐ SIMULINK

Send information on application-specific toolboxes for:

- | | | |
|--|--|---------------------------------------|
| <input type="checkbox"/> Signal Processing | <input type="checkbox"/> Simulation | <input type="checkbox"/> Optimization |
| <input type="checkbox"/> Image Processing | <input type="checkbox"/> Control System Design | <input type="checkbox"/> Statistics |
| <input type="checkbox"/> Symbolic Math | <input type="checkbox"/> Real-Time Control | <input type="checkbox"/> Fuzzy Logic |
| <input type="checkbox"/> Neural Networks | <input type="checkbox"/> System Identification | <input type="checkbox"/> Chemometrics |

Computer platform — check all that apply:

- ☐ PC or Macintosh ☐ UNIX Workstation ☐ VAX or Supercomputer

For the fastest response • Call us at 508-653-1415 • Fax to 508-653-6284 • Email to info@mathworks.com

NAME _____

EMAIL _____

TITLE _____

COMPANY _____

DEPT. OR M/S _____

ADDRESS _____

CITY/ STATE/ZIP _____

PHONE _____

FAX _____

R-AD-IEE-0395/21540/KP26



IMULINK Products

IMULINK Accelerator
Real-Time Workshop
Fixed-Point Blockset
Nonlinear Control Design
Toolbox

IMULINK Toolboxes

Control System Design
Robust Control
Analysis and Synthesis
Model Predictive Control
Adaptive Feedback Theory
Fuzzy Logic
System Identification
Symbolic Math

Frequency Domain System
Identification
• Symbolic Math
• Higher-Order Spectral Analysis

Free guide ■ rapid prototyping

Get into high gear today by calling for our comprehensive *Rapid Prototyping Guide* and a SIMULINK technical brochure.

Call today:
508-653-1415



24 Prime Park Way, Natick, MA 01760-1500
Tel: (508) 653-1415 Fax: (508) 653-6284
Email: info@mathworks.com

The MathWorks is represented in the following countries:
Australia: +61-2-922-6311 • Brazil: +55-11-816-3144
France: +33-1-45-34-23-91 • Germany: +49-241-26041
India: +91-80-2-260-260 • Israel: +972-3-561-5151
Italy: +39-11-24-85-332 • Japan: +81-3-5978-5410
Korea: +82-2-517-1257 • Portugal: +34-3-415-49-04
Scandinavia: +46-8-15-30-22 • Spain: +34-3-415-49-04
Switzerland: +41-31-998-44-11 • Taiwan: +886-2-501-8787
For Belgium, Luxembourg, The Netherlands, United Kingdom and Republic of Ireland call Cambridge Control, Ltd: +44-1223-423-200 or Rapid Data, Ltd: +44-903-821-266

MATLAB and SIMULINK are registered trademarks, and Real-Time Workshop is a trademark of The MathWorks, Inc.

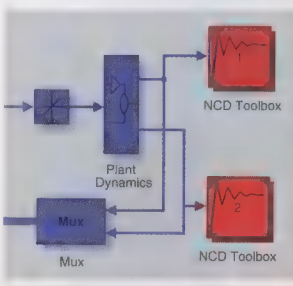
Gear up your simulation without spinning your wheels.

SIMULINK is a powerful, interactive environment for modeling, analysis, and system simulation. With over 7,000 users worldwide, SIMULINK has been proven to be effective in the design of vehicle power trains, aircraft, satellites, industrial processes, and disk drives.

To learn how SIMULINK can speed up your own design process, ask for our *Rapid Prototyping Guide*.

Create models graphically

With SIMULINK's intuitive GUI, you can model systems quickly and easily. Just drag and drop



By using gradient search methods, the Nonlinear Control Design Toolbox optimizes parameters—automatically.

and build reusable custom block libraries that you can share with your entire department or with outside contractors.

Real-time testing

Real-Time Workshop™ offers an open systems approach to rapid prototyping—one of the hottest innovations in design.

Real-Time Workshop generates C code from block diagrams, enabling you to reduce your design cycles dramatically and deliver products ahead of schedule.

The Ultimate Technical Computing Environment™

MATLAB and SIMULINK provide an extensible, interactive Technical Computing Environment that seamlessly integrates computation, visualization, and modeling on Macintosh, 386/486 and Pentium-based PCs, and Unix workstations.

Distrib IEEE 4 Contro Ether

The
**MATH
WORKS**
Inc.



The GPIB-
TCP/IP- Ethernet to IEE

- Control several systems from a networked com
- Share GPIB per between severa computers
- Includes NI-488.2™ driver software for Windows, Mac OS, HP-UX, or Sun Solaris
 - Removes TCP/IP Ethernet and GPIB complexity
 - Uses familiar NI-488.2 functions and development utilities
 - Is compatible with LabVIEW® and LabWindows®/CVI GPIB libraries

**Call for your
FREE GPIB
brochure
(800) 433-3488**



**NATIONAL
INSTRUMENTS™**
The Software is the Instrument®

6504 Bridge Point Parkway
Austin, TX 78730-5039
Tel: (512) 794-0100
Fax: (512) 794-8411

Branch Offices:

Australia 03 879 9422 • Austria 0662 435986
Belgium 02 757 00 20 • Canada 519 622 9310
Denmark 45 76 26 00 • Finland 90 527 2321
France 1 48 14 24 24 • Germany 089 741 31 30
Italy 02 48301892 • Japan 03 3788 1921
Mexico 95 800 010 0793 • Netherlands 03480 33466
Norway 32 84 84 00 • Singapore 2265886
Spain 91 640 0085 • Sweden 08 730 49 70
Switzerland 056 20 51 51 • Taiwan 02 377 1200
U.K. 01635 523545

© Copyright 1995 National Instruments Corporation. All rights reserved. Product and company names listed are trademarks or trade names of their respective companies.

Circle No. 13

BUSINESS REPLY MAIL

FIRST CLASS MAIL PERMIT NO. 82 NATICK, MA

POSTAGE WILL BE PAID BY ADDRESSEE

The MathWorks, Inc.
24 Prime Park Way
Natick, MA 01760-9889

NO POSTAGE
NECESSARY IF
MAILED IN THE
UNITED STATES



quotes, preferring instead to cull quotations that suit his agenda.

In my case, Taubes just made it all up. For the record, I would never have said that the "bulk of EMF research is paid for by the military" because for most of the last decade the military has hardly funded any studies at all.

Allow me one of many possible examples of Taubes's selective reporting: his dismissal of an association between EMFs and breast cancer. Taubes makes it sound as if the only reason for the growing suspicion that EMFs may promote breast cancer is a report from the Johns Hopkins University (JHU) School of Hygiene and Public Health of two cases among male workers, which was later "played...up widely" by the press.

Let's look at the facts: The JHU group announced the findings in November 1989 at a Department of Energy Conference as part of a larger set of results showing an association between EMF work and many different types of cancer, particularly leukemia. These findings might have passed unnoticed because no reporter attended the conference other than me.

The JHU researchers did not rush into print. They did not publish their results until March 1991—16 months later—and only after two other groups, one in the United States and one in Norway, published similar findings.

In addition, the JHU researchers identified six cases of male breast cancer, not two as Taubes reported. The other four

on the second line of the second column in the Viewpoint on p. 32 of the January issue, the T1 speed ought to have been 1.544 Mb/s.

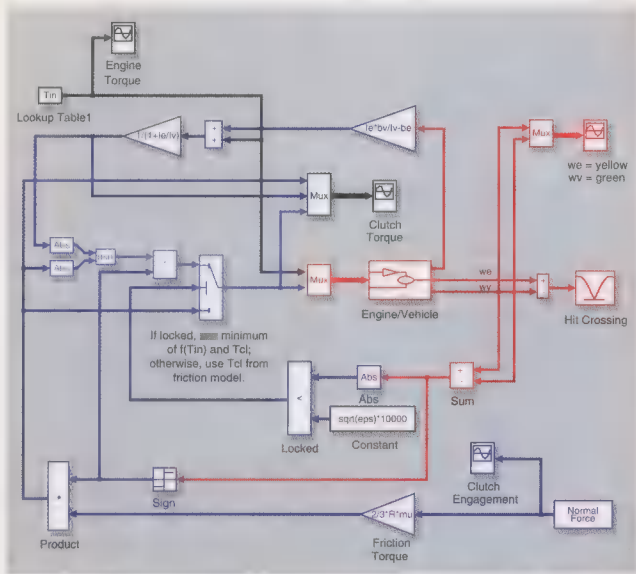
On the 14th line of the first paragraph in the first column on p. 37, the on-chip unified secondary cache memory should have been 94KB.

In the graph on p. 58, the four lowest values of average electricity rates in dollars per kilowatt-hour should have been given as 0.02, 0.04, 0.06, and 0.08.

In the box on p. 90, the e-mail address for the Transactions Department should have been given as trans@ep.ieee.org.

The *Proceedings* of the 16th Annual Conference of the IEEE Engineering in Medicine and Biology Society, which was held Nov. 3–6, 1994 [January 1995, p. 89], is available both on a CD ROM and in printed form. The disk is obtainable from Meeting Management, 2603 Main St., Suite 690, Irvine, CA 92714; 714-752-8205. The printed two-volume set may be obtained from the IEEE Service Center, Box 1331, Piscataway, NJ 08855; 800-678-IEEE. —Ed.

Readers are invited in this department to comment on material previously published in *IEEE Spectrum*, on the policies and operations of the IEEE, and on matters of technical, economic, or social interest to the electrical and electronics engineering profession. Contact: Forum, *IEEE Spectrum*, 345 E. 47th St., New York, NY 10017, U.S.A.; fax, 212-705-7453. The e-mail (Internet) address is n.hantman@ieee.org.



This block diagram is used to simulate the lookup of automotive clutch, providing greater insight into the transfer of engine torque to the driving wheels.

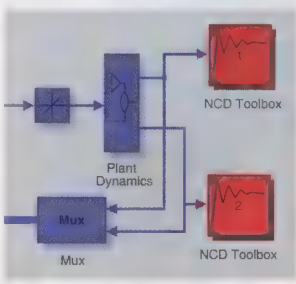
Gear up your simulation without spinning your wheels.

SIMULINK is a powerful, interactive environment for modeling, analysis, and system simulation. With over 7,000 users worldwide, SIMULINK has been proven to be effective in the design of vehicle power trains, aircraft, satellites, industrial processes, and disk drives.

To learn how SIMULINK can speed up your own design process, ask for our *Rapid Prototyping Guide*.

Create models graphically

With SIMULINK's intuitive GUI, you can model systems quickly and easily. Just drag and drop



By using gradient search methods, the Nonlinear Control Design Toolbox optimizes parameters—automatically.

icons into block diagrams—without writing a single line of code.

Extensive model types

SIMULINK provides over 200 built-in block types that simplify your model building. You can accurately model your system's behavior by combining a wide variety of block types. These include linear, nonlinear, and logic elements defined as continuous-time, discrete-time, or hybrid systems.

An open architecture

SIMULINK's open architecture lets you easily create custom blocks, modify existing blocks, and build reusable custom block libraries that you can share with your entire department or with outside contractors.

Real-time testing

Real-Time Workshop™ offers an open systems approach to rapid prototyping—one of the hottest innovations in design.

Real-Time Workshop generates C code from block diagrams, enabling you to reduce your design cycles dramatically and deliver products ahead of schedule.

The Ultimate Technical Computing Environment™

MATLAB and SIMULINK provide an extensible, interactive Technical Computing Environment that seamlessly integrates computation, visualization, and modeling on Macintosh, 386/486 and Pentium-based PCs, and Unix workstations.



SIMULINK Products

- SIMULINK Accelerator
- Real-Time Workshop
- Fixed-Point Blockset
- Nonlinear Control Design Toolbox

MATLAB Toolboxes

- Control System Design
- Robust Control
- μ -Analysis and Synthesis
- Model Predictive Control
- Quantitative Feedback Theory
- Fuzzy Logic
- System Identification
- Symbolic Math
- Frequency Domain System Identification
- Symbolic Math
- Higher-Order Spectral Analysis

Free guide to rapid prototyping

Get into high gear today by calling for our comprehensive *Rapid Prototyping Guide* and a SIMULINK technical brochure.

Call today:
508-653-1415



24 Prime Park Way, Natick, MA 01760-1500
Tel: (508) 653-1415 Fax: (508) 653-6284
Email: info@mathworks.com

The MathWorks is represented in the following countries:
Australia: +61-2-922-6311 • Brazil: +55-11-816-3144
France: +33-1-45-34-23-91 • Germany: +49-241-26041
India: +91-80-2-260-260 • Israel: +972-3-561-5151
Italy: +39-11-24-85-332 • Japan: +81-3-5978-5410
Korea: +82-2-517-1257 • Portugal: +34-3-415-49-04
Scandinavia: +46-8-15-30-22 • Spain: +34-3-415-49-04
Switzerland: +41-31-998-44-11 • Taiwan: +886-2-501-8787
For Belgium, Luxembourg, The Netherlands, United Kingdom and Republic of Ireland call Cambridge Control, Ltd: +44-1223-423-200 or Rapid Data, Ltd: +44-903-821-266

MATLAB and SIMULINK are registered trademarks, and Real-Time Workshop is a trademark of The MathWorks, Inc.

books

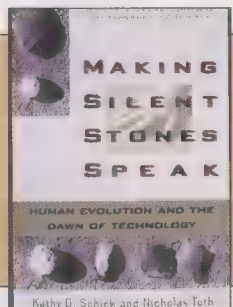
Learning from the Stone Age

KAREN R. ROSENBERG

Readers of *IEEE Spectrum* may be surprised to find two-million-year-old stone tools at the core of anything reviewed in these pages. The authors of this informative and entertaining book, however, would find it entirely appropriate. They see a continuum from the simplest technology of early humans to the late twentieth-century-world of electronics on which we have come to depend. In fact, they contend, even the tool use of nonhumans like mud wasps, Galapagos Island finches, Egyptian vultures, California sea otters, and chimpanzees could be considered technology. They write:

"At this moment we are writing on a portable computer, traveling hundreds of

Making Silent Stones Speak: Human Evolution and the Dawn of Technology. Schick, Kathy D., and Toth, Nicholas, a Touchstone book published by Simon and Schuster, New York, 1993, 352 pp., \$13.



miles per hour through a dark and starry night in the last row of the upper deck of a 747 airliner, on our way to yet another archaeological research project to explore some of humankind's oldest tool-making traditions. There is something philosophically pleasing about exploring the world's most ancient and rudimentary technologies with the assistance of some of the most sophisticated contemporary ones....and, as we hope the reader

will come to appreciate, there is no accidental relationship between the two."

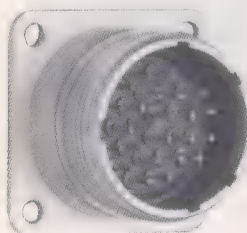
For authors Schick and Toth, modern technology is the "legacy of an unbroken chain of learned tool-making and tool-using behavior [which] can be traced back to the dawn of human technology and the emergence of hominid populations that made and used the simplest flaked stone tools

some two and a half million years ago on the African continent."

They argue that the centrality of technology to our life-style has had a profound effect on our evolutionary history. "Since tool-making achieved this critical role in our lives, humans have always lived in a 'technological age,'" they write.

The authors have made this account readable and indeed enjoyable by including short, dramatic narratives of early

MSC/EMAS ends wasted design time.

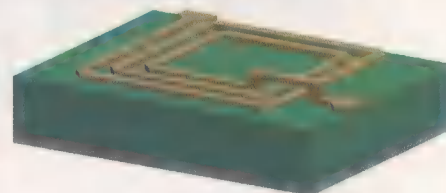
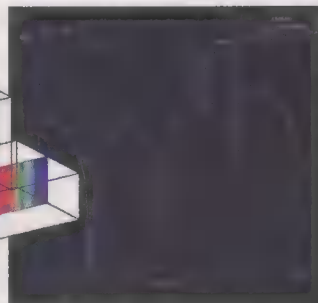
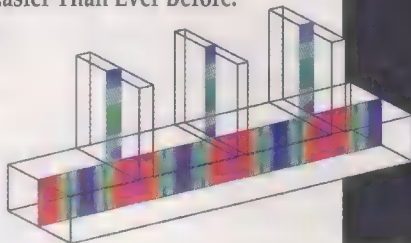


Using MSC/EMAS for Predictive Engineering.

With MSC/EMAS, electrical engineers and designers can rapidly create and analyze computerized 3D models to predict electromagnetic design parameters and field behavior. Design alternatives can then be easily explored by making changes to the model - all without building a single prototype.

EM Simulation is Easier Than Ever Before.

MSC/EMAS allows designers to build their components in a few hours, using convenient solid geometry and automeshing.



Results are Clear and Easy to Understand.

Design parameters can be graphed versus time, frequency or location. Insightful colorful pictures highlight problem areas and allow for quick comparisons to design specifications. Propagating fields can be viewed using the automated animation capability.


Simply Powerful.™

MSC The MacNeal-Schwendler Corporation




Call 414-357-8723 for more information.

See us at NDES '95 Booth #1624

Circle No. 9

Many control systems engineers don't know about the MATRIX_x® product family from Integrated Systems. Still, it's revolutionizing the way they develop software.  Each MATRIX_x product is the best in its class. Together, this integrated family of tools is the only

Developers Stunned As Family OF Five Begins To Control The World.

dependable solution for simple or complex control system design.  Run from a PC or workstation, MATRIX_x guides you through the design process, allowing you to evaluate and modify system models as you go. So you can be confident you'll get the best performance possible.  And unlike products mathematicians design for classrooms, MATRIX_x is solving real-world design problems, day in and day out. So if you need modeling and simulation tools, or a proven concept-to-code solution, MATRIX_x is the answer.  Maybe it's time you met the family. Call 1-800-770-3338 for info.



SystemBuild™
The core of the MATRIX_x modeling and simulation environment, has proved itself at automotive, satellite, batch and continuous process designs.

AutoCode®
software automatically generates well-documented, high-quality code from SystemBuild models.

Our seamlessly integrated AC-100™ hardware is part of our flexible™ Service—provides quick, convenient hardware in the back-trading with design team efforts.

Simeth™
software enables analysis and visualization efforts.

Document™
software saves engineers both time and trouble by automatically creating FrameMaker or Interleaf documents from SystemBuild models.

© 1999 Integrated Systems, Inc. Simeth and MATRIX_x are registered trademarks and AC-100, Document, SystemBuild, AutoCode and Service are trademarks of Integrated Systems, Inc. All other trademarks and registered trademarks are property of their respective holders.

books

hominids engaged in activities like making stone tools, butchering scavenged animals, and consuming the meat. They also describe the process by which human artifacts, workshops, and trash become archaeological sites, and they explain what it is like to be an archaeologist, both in the field and in the laboratory. Even in geographical terms, the book covers a lot of ground—the authors have done field work in East Africa, China, and the New Guinea Highlands.

Over the last decade or so, paleoanthropologists have written a number of books for a popular audience. What makes this book stand out from the others is its emphasis on the scientific process of archeology, rather than on the petty squabbles and jealousies in our field, which so often (unfortunately) dominate the popular media. The authors approach stone tools as part of a technological and cultural system, instead of simply as isolated objects of intrinsic interest. Their analysis is organized around various stages in the manufacture and use of such tools, includ-

ing the acquisition and transport of raw material, tool production, tool modification during use, as well as ultimately, their discarding and archaeological discovery.

What I particularly like is that this book answers the question, "How do archeologists learn from bits of stone and trash how people lived millions of years ago?" It is not just about what happened in human prehistory, but about the process of discovery of what happened in human prehistory. The authors put a lot of effort into unraveling the process by which archeologists go from lumps of stone, which they recognize as having been worked by early humans (their "data"), to statements about the behavior of our ancestors two-and-a-half-million years ago and the importance of technology in their (and our) life-styles.

Focusing primarily, though by no means exclusively, on their own research, Schick and Toth describe several approaches they have used. Besides dealing with tool use and tool-making in other animals, as mentioned above, they explain the stages of analysis of artifacts collected from archeological sites.

Finally, they discuss their involvement in "experimental archeology." In order to

understand how stone tools were manufactured, they spent many long hours making their own stone tools. They then used the tools to understand how the artifacts might work in different functional contexts and to examine the wear that such use might leave on them.

In one memorable description, the authors tell of butchering the "world's largest terrestrial mammal," an elephant, using the "world's simplest flaked stone technology." Noting that the elephant died of natural causes, the authors admit that "the sight of a twelve-thousand-pound animal carcass the size of a Winnebago can be quite intimidating," but report their amazement that the small lava flakes they had produced were extremely effective at cutting up the remains.

To ascertain how archaeological sites come to be buried, the authors created experimental sites in various locations. They labeled and recorded the position of "artifacts" and then examined the region following a flood to determine what effects the event had had on the placement and condition of the stone tools, animal bones, and the site itself.

Even to look at, this book is both infor-

OPTOELECTRONICS

— Devices and Technologies —

"OP-DET" is a quarterly journal dealing with the interaction of photons and electrons, and related devices and technologies. It publishes original papers and review articles on all areas of optoelectronics: basic phenomena, materials processing, optoelectronic devices, optoelectronic systems, and so on.

Editors-in-Chief

Makoto Kikuchi
Executive Technical Adviser
SONY Corporation, Japan

Yoshihiro Hamakawa
Professor
Osaka University, Japan

Publishing Schedule, 1995~

Vol. 10, No.1 March '95: Focus on *Optical Fiber Communication*

Vol. 10, No.2 June '95: Focus on *Nanometer Manipulation*

Vol. 10, No.3 September '95: Focus on *Optical Memory and Image Storage*

Vol. 10, No.4 December '95: Focus on *Physics and Technologies of Femto-second*

Vol. 11, No.1 March '96: Focus on *Synchrotron Orbit Radiation*

Subscription Rates	Rates for One Year		Rates for Three Years	
	<input type="checkbox"/> Institution	<input type="checkbox"/> Individual	<input type="checkbox"/> Institution	<input type="checkbox"/> Individual
In Japan (Includes Postage)	¥30,900	¥18,540	¥90,000	¥54,000
Outside Japan	US\$125	US\$65	US\$355	US\$185
Surface Postage	US\$5		US\$15	
Airmail Postage	US\$35		US\$105	

mita

MITA PRESS

3-2-12, Hongo, Bunkyo-ku, Tokyo 113, Japan
Tel. 03(3818)1011 / Fax. 03(3818)1016

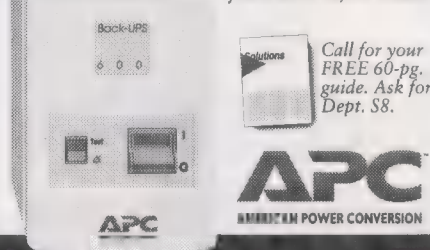
Circle No. 12

It's not if, it's when...

Power problems are the largest cause of data loss on your PC. Get complete protection for just \$119!

Don't come out on the losing end of a struggle with your utility line. Starting at \$119 list, Uninterruptible Power Supplies from APC provide instant battery backup to save your work in progress and protect your hard drive, plus up to a \$25,000 guarantee (see details) against surge damage to equipment.

So ask for APC...it's not if you'll need us, it's when.



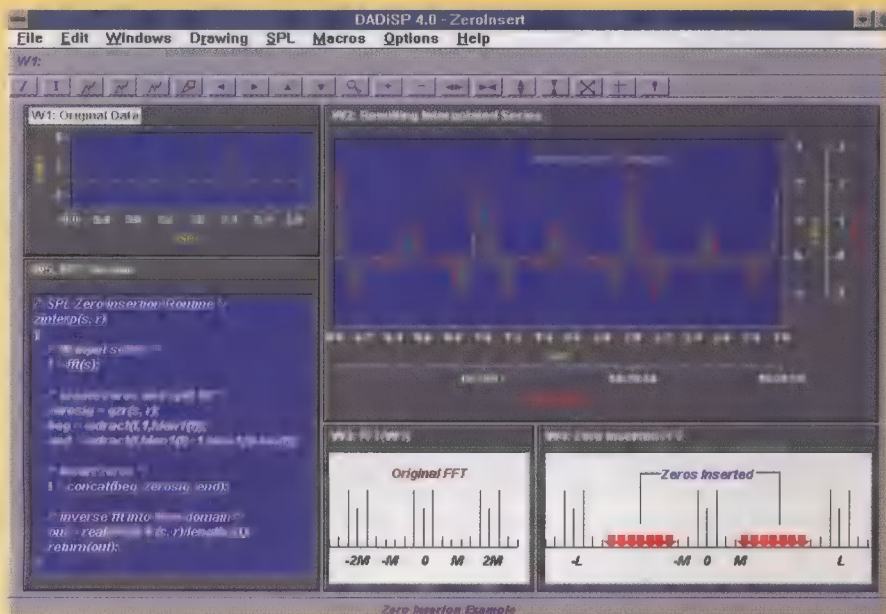
800-800-4APC

Circle No. 5

IN CASE YOU MISSED IT!

Here's what **they*** said about DADiSP 4.0

A streamlined user interface that fully conforms to Windows is the first obvious feature of a long-awaited upgrade to DADiSP, a graphical analysis program from DSP Development Corp. that's designed for the needs of scientists and engineers.



A major overhaul of the user interface, the introduction of an integrated programming language and new option modules highlight Ver. 4.0 of DADiSP...

Besides adopting a complete Windows look and feel, the overall interface scheme has gained a more streamlined look... [W]ith the flattened hierarchy on this upgrade, the software always starts up in a worksheet; indeed, when loaded, the software returns to the setup that was on the screen when the user last exited the program. Although you don't have to go through a hierarchy, the package still maintains labbooks, datasets and worksheets to provide a simple method of organizing large complex datafiles and projects.

As part of the Windows implementation, Ver. 4.0 adds support for DDE as a client or server either with functions at the command line or with Copy/Paste Link for the pulldown menu. It performs both warm and hot DDE links with either ASCII or binary datatypes...

Ver. 4.0 also gives users the ability to define their own operations and functions to a far greater extent than the macros found in the previous version. Specifically, the upgrade marks the introduction of a programming language called SPL (series processing language). Modeled on C, it provides all the expected facilities including user-defined functions, looping and iteration, conditional statements, array references and variables. Variables can be global to a session or local to a function.

An interesting feature is the hot variable, which can contain real or complex numbers, strings, data series and matrices. A hot variable links a formula to a variable so that when a dependent element of a formula changes, the hot variable automatically reevaluates. For example, the SPL code fragment:

```
size := 10  
W2: Movavg(W1, size)
```

performs a 10-point moving average on the waveform in Window 1 and displays the results in Window 2. The := operator establishes the hot variable. You can explore the effects of changing the moving-average length simply by reassigning size := 20 so that W2 automatically updates and shows a plot based on that new parameter.

Also improved is the package's hardcopy facility. Plot titles, legends, multiple scales, selectable fonts and a Preview mode help users produce publication-quality output...

[T]wo more modules... address advanced DSP and control applications. The AdvDSP module performs Chirp-Z transforms, N-point FFTs independent of series length and zoom FFTs. It also handles multiple forms of PSD estimation (classical, autoregressive parametric, moving-average parametric, autoregressive moving-average parametric), transfer-function estimates, Cepstrum analysis and digital interpolation. The controls module allows you to execute command line or pulldown menus, and it addresses the design, analysis and simulation of digital and continuous open- and closed-loop controllers for linear single-input/single-output dynamic systems. Among its algorithms are those that handle PID loops as well as lead and lag controllers.

* Personal Engineering & Instrumentation News 1/95



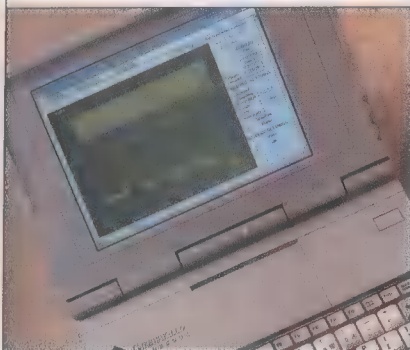
For a Free TRIAL

Call today: 1-800-777-5151

Circle No. 6

**DSP**
Development
Corporation
One Kendall Square, Cambridge, MA 02139
617-577-1133, FAX: 617-577-8211

Portable Data Acquisition



Performance and Portability – We Give You Both.

DAQPad™-1200

- Parallel port interface
- 100 ksamples/s
- 8 analog inputs, 2 analog outputs, 24 digital I/O lines, 3 counter/timers
- DC power, optional battery pack



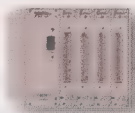
DAQCards™

- Type II PCMCIA cards
- 100 ksamples/s
- 16 analog inputs
- 24 digital I/O lines
- 2 counter/timers



SCXI

- Parallel port or PCMCIA interface
- Signal conditioning and data acquisition
- Expandable to 128 channels
- DC power, optional battery pack



Software

- NI-DAQ® driver software for:
 - LabVIEW®
 - LabWindows®/CVI
 - Basic, C/C++, Visual Basic, Pascal, and many more



Call for FREE
DAQ Designer™ Software
(800) 433-3488 (U.S. and Canada)

NATIONAL INSTRUMENTS™
The Software is the Instrument®

Tel: (512) 794-0100
 Fax: (512) 794-8411
 E-mail: info@natinst.com

© Copyright 1995 National Instruments Corporation. All rights reserved. Product and company names listed are trademarks or trade names of their respective companies.

books

mative and fun. Figures illustrating stone tools and animal and early human bones, as well as archaeologists at their work, adorn nearly a third of the pages. But the authors are at bottom quite serious.

They argue that archaeology has something substantive to contribute to the world outside the confines of studies of stone age tools. After reminding readers that extinction is the norm for species, they propose that "our hope of continuing as a species into the future will lie in our ability to come to grips with our technological systems and to overcome their potentially destructive consequences."

To win through, they contend, people must gain an understanding of how technology came to be so central to our way of life. This book is a fine and engaging survey of the beginnings of that process.

Karen R. Rosenberg is an associate professor in the department of anthropology at the University of Delaware in Newark. Her research focuses on the fossil evidence for human evolution. She has studied human skeletal remains in Central Europe, the Middle East, Southeast Asia, China, and the Delmarva Peninsula in the United States. Her published work includes writings on prehistoric health and diet in the Mid-Atlantic region, Neanderthal pelvic morphology, and the evolution of modern human childbirth.

recent books

Worldwide Advances in Communication Networks. Ed. Jabbari, Bijan, Plenum Publishing, New York, 1994, 185 pp., \$69.50.

Coherent Lightwave Communications Systems. Ryu, Shiro, Artech House, Boston, 1995, 283 pp., \$79.

Optical Engineering Fundamentals. Walker, Bruce H., McGraw-Hill, New York, 1995, 341 pp., \$40.

Algorithmic Learning. Hutchinson, Alan, Oxford University Press, New York, 1994, 434 pp., \$90 (hardcover), \$42.50 (paperback).

Automotive Sensors. Westbrook, M.H., and Turner, J.D., Institute of Physics Publishing, Philadelphia, 1994, 272 pp., \$149.

Operational Amplifier Circuits: Analysis and Design. Nelson, John C.C., Butterworth-Heinemann, Woburn, Mass., 1995, 138 pp., \$22.95.

Thermal Sensors. Meijer, G.C.M., and van Herwaarden, A.W., Institute of Physics Publishing, Philadelphia, 1994, 320 pp., \$150.

Advanced Microprocessors, 2nd edition. Tabak, Daniel, McGraw-Hill, New York, 1995, 523 pp., \$60.

Adventures in Space Simulator: The Ultimate Desktop Astronaut's Guide. Fjermedal, Grant, Microsoft Press, Redmond, Wash., 1994, 245 pp., \$22.95.

Smart Highways, Smart Cars. Whelan, Richard, Artech House, Boston, 1995, 231 pp., \$59.

Two-Dimensional Imaging. Bracewell, Ronald N., Prentice Hall, Englewood Cliffs, N.J., 1995, 689 pp., \$66.67.

The CG-FTT Method: Application of Signal Processing Techniques to Electromagnetics. Catedra, Manuel F., et al., Artech House, Boston, 1995, 361 pp., \$95.

Bugs in Writing: A Guide to Debugging Your Prose. Dupre, Lyn, Addison-Wesley, Chicago, 1995, 649 pp., \$19.95.

Mobile Telecommunications: Emerging European Markets. Eds. Schenk, Karl-Ernst, et al., Artech House, Boston, 1995, 328 pp., \$69.

UNIX System Administration Handbook, 2nd edition. Nemeth, Evi, et al., Prentice Hall, Englewood Cliffs, N.J., 1995, 361 pp., \$48 (with CD ROM included).

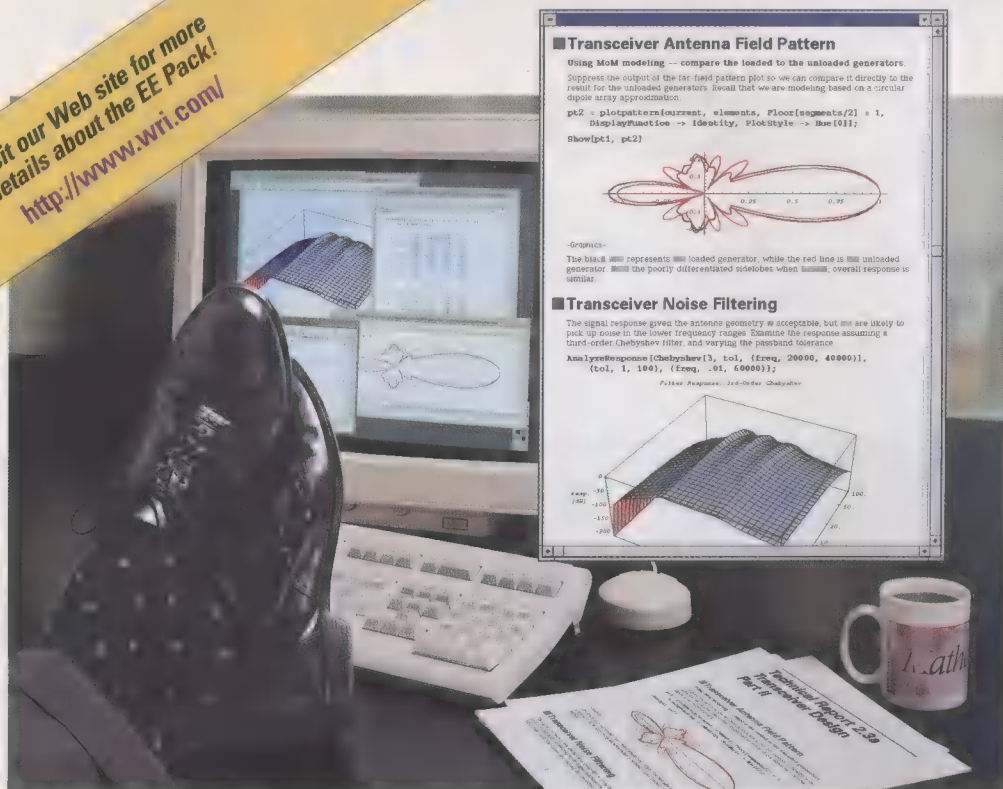
Migrating to Object Technology. Graham, Ian, Addison-Wesley, Reading, Mass., 1995, 552 pp., \$45.25.

The Handbook of Optics, 2nd edition, Vol. I: Fundamentals, Techniques, and Design; Vol. II: Devices, Measurements, and Properties. Ed. Bass, Michael, et al., McGraw-Hill, New York, 1995, 1400 and 1200 pp., respectively, \$99.50 each.

How to Solve Problems: For Success in Freshman Physics, Engineering, and Beyond, 4th edition. Scarl, Donald, Doris Press, Glen Cove, N.Y., 1994, 127 pp., \$8.95.

The Future of Software. Ed. Leebaert, Derek, MIT Press, Cambridge, Mass., 1995, 300 pp., \$24.95.

Visit our Web site for more details about the EE Pack!
<http://www.wri.com/>



Relax. Modeling and analysis with *Mathematica*® puts you ahead of schedule.

Every step in the design process takes time. Before you commit to a physical prototype, you've got calculations to do, equations to solve, data to analyze, design parameters to test, simulations to run, and results to document. The more you nail down before you turn to hardware, the more efficient you become.

Mathematica is a uniquely powerful modeling environment that combines it all for engineers—putting a diverse and extensible range of ready-to-use capabilities right on your desktop.

The hundreds of mathematical functions and spectacular 2D and 3D graphing capabilities provided in *Mathematica* are easy to use, helping you visualize your solutions and data from every angle imaginable. Simply type in the problem, and your answer appears.

Mathematica brings all your tools together in a single software system, moving you effort-

lessly between numeric and symbolic computation, visualization, and document preparation.

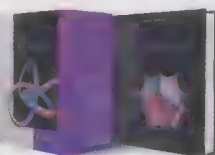
Engineers around the world rely on *Mathematica* as they design all types of systems, from circuits to antennas, signal processing devices, radar systems, and many others. Put it to work for you as you create models, define parameters, analyze prototypes, and simulate entire system designs.

Call us today for more on how *Mathematica* can speed you through modeling and design tasks from start to finish.

1-800-441-MATH

(U.S. and Canada)

Ask for Ext. 50



Wolfram Research

Mathematica is available for: Macintosh, Power Macintosh • Microsoft Windows, Windows NT • MS-DOS • IBM OS/2 • Sun SPARC • DEC OSF/1 AXP, OpenVMS AXP, RISC Ultrix, VAX/VMS • HP • Hitachi • IBM RISC • NEC PC • NEC EWS • NEXTSTEP • SGI • CONVEX • and others.

Corporate headquarters: **Wolfram Research, Inc.**, +1-217-398-0700; fax: +1-217-398-0747; email: info@wri.com; WWW: <http://www.wri.com/>; Europe: **Wolfram Research Europe Ltd.**, +44-(0)1993-883400; fax: +44-(0)1993-883800; email: info-europe@wri.com; Asia: **Wolfram Research Asia Ltd.** (Tokyo office), +81-(0)3-5276-0506; fax: +81-(0)3-5276-0509; email: info-asia@wri.com.

© 1995 Wolfram Research, Inc. *Mathematica* is a registered trademark of Wolfram Research, Inc. *Mathematica* is not associated with Mathematica Policy Research, Inc. or MathTech, Inc. All other product names mentioned are trademarks of their producers.

Circle No. 17

Numeric and Symbolic Mathematics

- matrix manipulation
- transforms—Fourier, Laplace, FFT
- nonlinear unconstrained optimization
- root finding
- equation solving
- differentiation
- integration
- complex numbers

Data Manipulation

- import and export data
- curve fitting
- statistics

Visualization

- 2D and 3D plotting and graphics
- output in PostScript and other standard formats

Extensible and Customizable

- high-level programming language
- easy to build and combine your own functions for custom solutions

Notebook Interface

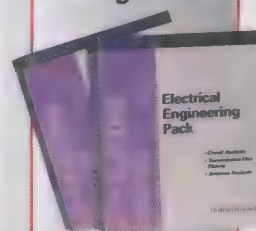
- ideal for documenting work in progress and writing technical reports
- text editing and document layout capabilities
- on-line help

NEW! Add-on Applications

- *Mathematica Electrical Engineering Pack* (see below)
- Nodal—circuit analysis and design
- links to Fortran and C libraries, Microsoft Excel, LabVIEW, and others
- electronic library contains hundreds of user-designed application packages (signal processing, neural networks, optics, etc.)

And much more!

Ideal Add-on for Engineers



Includes specialized functions and practical examples for:

- circuit analysis
- transmission lines
- antenna analysis
- and more

Put the pack's tools to work for you today!

calendar

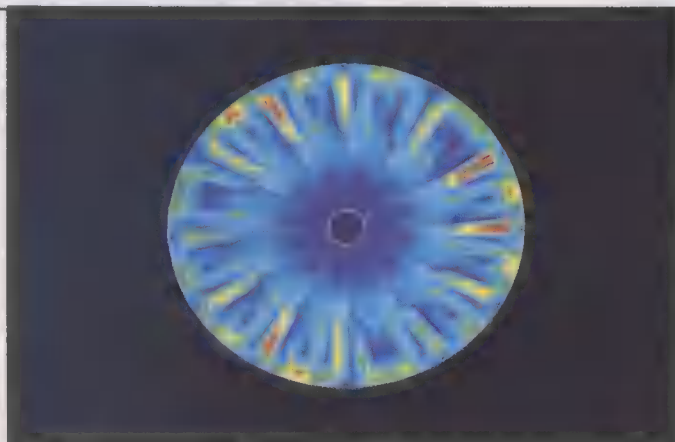
march

Virtual Reality International Symposium (NN, C); March 11-15; Sheraton Imperial Hotel and Convention Center, Research Triangle Park, N.C.; Jim Cone,

2603 Main St., Suite 690, Irvine, CA 92714; 714-752-8205; fax, -752-7444; e-mail, 74710.2266@compuserve.com.

Ultrafast Electronics and Optoelectronics Topical Meeting (ED);

March 13-17; Dana Point Resort, California; Ellen Murphy, Optical Society, 2010 Massachusetts Ave., N.W., Washington, DC 20036; 202-416-1995; fax, 202-416-6100.



Flux density in a permanent magnet motor.

THERE ARE SLOWER EM PROGRAMS, BUT THEY COST A LOT MORE.

Now the fastest and easiest way to solve electromagnetic problems is also one of the least expensive. COSMOS/EM from Structural Research.

Our new, proprietary solution technique is 50 to 100 times faster than conventional methods ... and uses less disk space. So you can solve complex problems fast. Right on your desktop.

**SOLVE EM PROBLEMS UP
TO 100 TIMES FASTER
FOR UNDER \$5000.**

You can perform 2D and 3D magnetostatics, AC eddy current and nonlinear transient analysis, electrostatics and current flow analysis. And

COSMOS/EM's powerful pre- and postprocessor makes modeling and displaying results virtually effortless.

All of which should make COSMOS/EM your choice to design and simulate electric motors, actuators, magnetic shields, permanent magnet systems, transformers and circuit boards.

Call 310-452-2158 extension 850 for a free limited version of COSMOS/EM. And find how much more a lot less money can buy.

COSMOS/EM

THE ULTIMATE TESTING GROUND FOR YOUR IDEAS.

Available for PC, Mac and EWS.

International Conference on Computer Applications in Engineering and Medicine (C); March 15-17; University Place Hotel, Indianapolis, Ind.; Mohamed El-Sharkawy, Department of Electronics Engineering, Purdue University, 723 W. Michigan St., Indianapolis, IN 46202; 317-274-4559; fax, 317-274-4493; e-mail, elshark@etsun.engr.iupui.edu.

International Forum on High Quality Digital Video and Its Impact (COM, SP); March 16-17; Waseda University, Tokyo; Sadayasu Ono, NTT Optical Networks Systems Laboratories, 1-2356 Take, Yokosuka, Kanagawa, 238-03, Japan; (81+468) 59 3240; fax, 59 3014; e-mail, forum@nttsd.ntt.jp.

European Workshop on Materials for Advanced Metalization (ED); March 19-22; Park Hotel Hoflohnitz, Radebeul, Germany; Stefan E. Schulz, TU Chemnitz-Zwickau, Zentrum für Mikrotechnologien, D-09107 Chemnitz, Germany; (49+371) 531 3683; fax, (49+371) 531 3131.

Fourth International Fuzzy Systems Conference (NN); March 20-24; Pacific Convention Plaza, Yokohama, Japan; Life, Siber Hegner Building 4F, 89-1, Yamashita-cho, Naka-ku, Kanagawa 243, Japan; (81+45) 212 8268; fax, (81+45) 212 8255.

IEEE members attend more than 5000 IEEE professional meetings, conferences, and conventions held throughout the world each year. For more information on any meeting in this guide, write or call the listed meeting contact. Information is also available from: Conference Services Department, IEEE Service Center, 445 Hoes Lane, Box 1331, Piscataway, NJ 80055; 908-562-3878; submit conferences for listing to: Ramona Foster, IEEE Spectrum, 345 E. 47th St., New York, NY 10017; 212-705-7305. For additional information on hotels, conference centers, and travel services, see the Reader Service Card.

Circle No. 20

Fly Your 3-D Data Base on a TRW RAMCUBE. Start Getting the Big Picture.

Three-dimensional data sets stored in TRW RAMCUBE solid state memory products can be transferred to your system at speeds up to 200 megabytes per second.

That means you can now "fly" through a data set approximately 100 times faster than you could with a conventional hard disk storage system.

Or expand your current 3-D data fly-throughs to a full screen format.

TRW RAMCUBE products can also create significant lift for your productivity.

Their solid state technology delivers access times hundreds of times faster than those available with conventional hard disk systems. Which means you can now run your most access-intensive applications whenever you like.

And never worry about stalling.

To learn more about the high speed, high capacity flight paths of TRW RAMCUBE solid state memory products, give us a call. We'll help you arrange a test flight.

1.800.795.4TRW

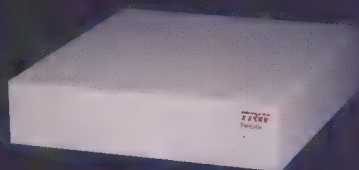
TRW Memory Systems
Systemic Integration Group
1800 Glenn Curtiss Street
Corona, CA 90746

TRW

© 1994 TRW Inc.



For data rates up to 200 megabytes per second over HIPPI, we recommend the TRW RAMCUBE 200.



The TRW RAMCUBE 2G delivers data at speeds up to 17 megabytes per second over the SCSI.



TRW RAMCUBE 350 offers SCSI with battery and disk backup, all in standard form factor.

calendar

National Radio Science Conference (ED); March 21-23; Alexandria University, Egypt; Ibrahim A. Salem, 17 Elqouba St., 3, Roxy Heliopolis, Cairo-11341, Egypt; (20+2) 258 0256; fax, (20+2) 349 8217.

International Conference on Micro-electronic Test Structures (ED); March 23-25; New Public Hall, Nara,

Japan; Loren W. Linholm, National Institute of Standards and Technology, B-360 Technical Building, Gaithersburg, MD 20899; 301-975-2052; fax, 301-948-4081; e-mail, linholm@sed.eel.nist.gov.

Signal Processing Workshop (MD/DC Chapter SP, NCAC); March 24-25; University of the District of Columbia, Van Ness Campus, Washington, D.C.; Edgar Neal, 11809 Collins Dr., Germantown, MD 20876; 301-258-

8301; fax, 301-258-9163; e-mail, rpierce@oasys.dt.navy.mil.

Seventh Workshop on Local and Metropolitan Area Networks (COM); March 26-29; Hawk's Cay Resort and Marina, Duck Key, Fla.; Yoram Ofek, IBM Corp., T. J. Watson Research Center, Box 704, Yorktown Heights, NY 10598; 914-784-7085; fax, -6205.

Southeastcon '95 (Region 3, East NC); March 26-29; North Raleigh Hilton,

THOUGHT PROCESS FUTURE

How do we master the
process of consistently safe,
effective production?

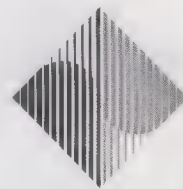


DECISION MAKING PROCESS INTERKAMA

INTERKAMA 95 is the world's Number One trade fair for measurement and automation technology. Every three years INTERKAMA presents the entire range of process technology, from measurement, control and regulation technology components to complete measurement and monitoring systems. INTERKAMA 95 offers an international forum for an exchange of ideas on applied technology solutions and the latest in research.


Nearly 100,000 visitors from around the world are expected to attend INTERKAMA 95. Over 1,500 exhibitors from 60 countries will display their newest products. Be part of the global marketplace at INTERKAMA 95!

Oct. 30 - Nov. 4, 1995
DUSSELDORF, GERMANY

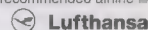


No. 1 trade fair for
measurement and
automation worldwide

For show and travel information:

 **Dusseldorf Trade Shows**
150 N. Michigan Ave., Suite 2920
Chicago, Illinois 60601
(312) 781-5180 FAX (312) 781-5188

Our recommended airline is



FOR IEEE MEMBERS ONLY

NOW IS THE TIME TO CONSIDER TAX-ADVANTAGED INVESTING

IEEE MAKES IT SIMPLE FOR MEMBERS TO SAVE ON TAXES WITH
LOW-INVESTMENT IRAS AND NO SALES CHARGES.



IEEE BALANCED FUND

Created exclusively for IEEE members, this no-load fund seeks to provide "balanced" investing, by combining the growth potential of stocks with current income from bonds.



VISTASM FAMILY OF MUTUAL FUNDS

Vista Broker-Dealer Services, Inc., is the Funds' distributor and is unaffiliated with Chase. The Chase Manhattan Bank, N.A., is the Portfolio adviser for the other Funds in the Vista Family of Mutual Funds.

The Chase Manhattan Bank, N.A., is the IEEE Balanced Fund's overall investment adviser, administrator and custodian. Atlanta Capital Management (with the Institute of Electrical and Electronics Engineers, Inc.) is the Fund's sub-adviser and manages the Fund's portfolio. Exchange privileges may be modified or terminated at any time. Call for prospectuses that contain more complete information including sales charges and expenses. Read them carefully before investing or sending money. *Taxes are due upon withdrawal from an IRA. If withdrawals occur prior to age 59 1/2 = 10% IRS

A fund family with over 20 investment choices, all managed by the investment professionals at Chase Manhattan, including a variety of tax-free bond and tax-free money-market funds.

IRAs — defer taxes with only a \$250 minimum investment.

No Sales Charges — saving members up to 5%.

SEP-IRA, 401k, 403b — and other qualified retirement plans available.

Free exchange privileges

Call 1-800-GET-IEEE

FOR MORE INFORMATION ON TAX-ADVANTAGED MUTUAL FUNDS, 24 HOURS A DAY, 7 DAYS A WEEK.

IEEE
FINANCIAL
ADVANTAGE
PROGRAM

Investments in the Funds are not deposits, obligations of, endorsed or guaranteed by Chase and are not insured or guaranteed by the FDIC, Federal Reserve Board or any other government agency. Investments in mutual funds are subject to risk that may result in loss of principal.

YOUR IEEE FINANCIAL ADVANTAGE IS JUST A SIMPLE PHONE CALL AWAY.

calendar

Raleigh, N.C.; Charles J. Lord, 108
Huntington Circle, Cary, NC 27513;
919-469-9682; e-mail, c.j.lord@ieee.org.

**Interpack '95: Towards Failure Free,
Low Cost Electronic Packaging**
(CPMT); March 26-30; Westin Maui,
Lahaina, Hawaii; Avram Bar-Cohen,
Department of Mechanical Engineering,

University of Minnesota, 111 Church
St., S.E., Minneapolis, MN 55455;
612-626-7244; fax, 612-624-1398.

**International Symposium on Require-
ments Engineering—RE '95 (C);**
March 27-29; York University, UK;
M. D. Harrison, Department of
Computer Science, University of York,
Heslington York, YO1 5DD, England;
(44+904) 432 732; fax, 432 767;
e-mail, math@minster.york.ac.uk.

International Verilog HDL Conference
(C); March 27-29; Santa Clara Con-
vention Center, Calif.; Hamid Butt, Ver-
tex Semiconductor, 1060 Rincon Circle,
San Jose, CA 95131; 408-526-2715;
fax, -9286; e-mail, hamid@ventex.com.

Data Compression Conference—DCC
'95 (C); March 28-30; Cliff Lodge,
Snowbird, Utah; James A. Storer,
Computer Science Department,
Brandeis University, Waltham, MA
02254; 617-736-2714; fax, -736-2741;
e-mail, storer@cs.brandeis.edu.

Fourth International Workshop on
Responsive Computer Systems
(CS); March 29-31; Hotel President,
Berlin; Volker Tschammer, GMD-
Fokus, Hardenbergplatz 2, D-10623
Berlin, Germany; (49+30) 254 99 226;
fax, (49+30) 254 99 202; e-mail,
tschammer@fokus.berlin.gmd.d400.d.

april

Infocom '95 (C, COM); April 2-6; Park
Plaza Hotel, Boston; Celia Desmond,
Stentor, Floor 6B, 33 City Center Dr.,
Mississauga, ON L5B 2N5, Canada;
416-615-6507; fax, 416-615-8421.

**International Conference on Tele-
communications (COM, Indonesia**
Section); April 3-5; Bali Hilton Hotel,
Indonesia; John Pearson, Electronic
Engineering Department, Kings
College London, Strand, London
WC2R 2LS, England; (44+71) 873
2850; fax, (44+71) 836 4781.

**International Reliability Physics Sym-
posium (ED);** April 3-6; Riviera Hotel,
Las Vegas, Nev.; Joseph W. McPherson,
Texas Instruments, Box 655012,
M/S 385, 13353 Floyd Rd., Dallas, TX
75243; 214-995-2183; fax, -2932.

**Second Topical Symposium on Com-
bined Optical, Microwave, Earth
and Atmosphere Sensing (GRS,
LEO, MTT);** April 3-6; Atlanta Re-
naissance, Georgia; Melissa Estrin,
IEEE/LEOS, 445 Hoes Lane, Box 1331,
Piscataway, NJ 08855; 908-562-3896;
fax, -8434; e-mail, m.estrin@ieee.org.

Joint Railroad Conference (VT); April
4-6; Baltimore Marriott Inner Harbor
Hotel, Maryland; Richard C. Tansill,
De Leuw, Cather & Co., 1133 15th St.,
N.W., Washington, DC 20005-2701;
202-775-3320; fax, 202-775-3389.

14th Southern Biomedical Engineering
Conference (EMB); April 8-9; Holi-
day Inn Downtown, Shreveport, La.;

INTELLIMOD

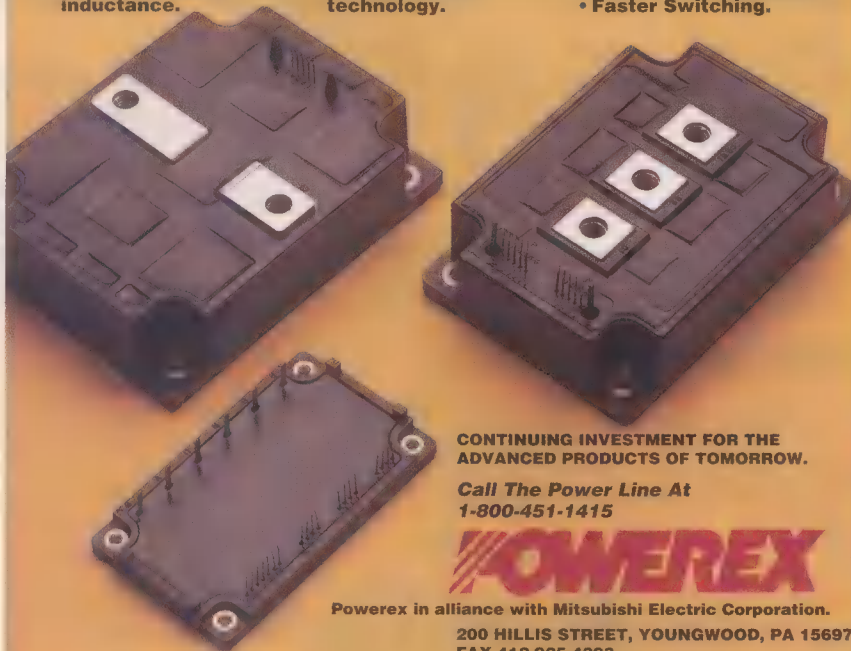
MORE POWER FROM POWEREX NEWLY DESIGNED THIRD GENERATION

20 KHZ SERIES

INTELLIGENT POWER MODULE.

**PROVIDES EXPANDED PERFORMANCE CAPABILITY
FOR MARKET INTRODUCTION IN HALF THE TIME.**

- 30% power loss reduction-improved VCE(SAT) and fall time (tf) trade-off.
- 3rd generation soft/fast recovery FWD.
- Easy to integrate components reduce circuit design costs.
- Closely coupled optimized IGBT and driver chip minimizes stray inductance.
- Failsafe protection for sensing over current, over temperature, gate drive under voltage and short circuit. New Real Time Control (RTC) reduces stress on chip and circuit during short circuit shutdown. P-Side fault output detects ground faults.
- Exclusive IGBT current sense technology.
- Single arrangement at 600A-1200V.
- 6 or 7-pack arrangement at 10A to 100A-1200V, 10A to 200A-600V.
- Dual arrangement at 75A to 300A-1200V, 200A to 400A-600V.
- 3rd generation component technology.
- Reduced package size.
- Totally isolated for quick easy installation.
- Faster Switching.



CONTINUING INVESTMENT FOR THE
ADVANCED PRODUCTS OF TOMORROW.

Call The Power Line At
1-800-451-1415

POWEREX

Powerex in alliance with Mitsubishi Electric Corporation.

200 HILLIS STREET, YOUNGWOOD, PA 15697
FAX 412-925-4393

Get this CD-ROM
FREE!

Here are just a few of
the titles on the
EvaluWare CD-ROM for
EE's and physicists:

Data Analysis & Visualization

PlotIT 3.1 for Windows
PDEase
Xmath
EasyPlot
BMDP New System
SigmaPlot
Vortex
Graphica
Interactive Image Display
Spectral Analysis on a PC
NONLIN
SIM2NL
SIMSTAT
KURV+ for Windows
GRAFPAPP

Symbolic & Numerical Math

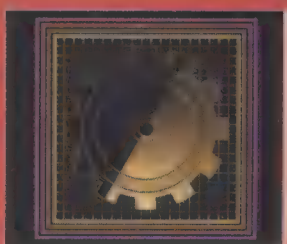
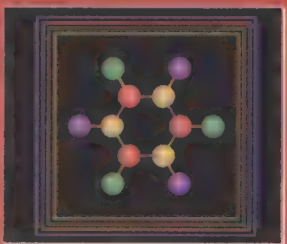
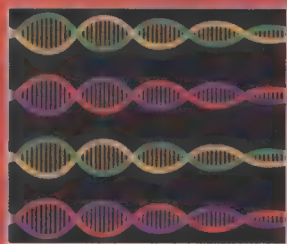
O-Matrix
Macsyma
AXUM 3.0
VisSim
PC Advantage
Math Advantage
Cumulative Binomial
Programs
SYMBMATH
ZGRAFWIN
FSU-ULTRA
Conversion Master
RPCalc32
MATHEXTRA

Electromagnetic Analysis

FEMIS
ELCUT
A Method of Moments Code
for Electromagnetic
Scattering
Microwave Beam Power
Transmission at an
Arbitrary Range

Neural Networks

Propagator
O'INCA Design Framework
A Neural Network
Development Tool
The Visible Neural Network
Neural Planner
NNTutor Intro



Introducing EVALUWARE

*The easy way to evaluate
engineering & scientific software
before you buy*

At last! An easy way to try out engineering and scientific software packages before you make a major investment. EvaluWare™ CD-ROMs put a multitude of specialized software packages at your fingertips -- so you can compare and evaluate them instantly. No more wasting time searching for hard-to-find applications. And no more wasting money on software that doesn't meet your needs.

Test drive more than 80 software packages

The EvaluWare CD-ROM is not just a catalog -- it contains actual, fully functional DOS and Windows™ based software packages for you to try out. These applications were selected specifically for EEs and physicists and include numerous commercial packages, the most useful programs from the NASA COSMIC library, and lots of hard-to-find shareware for you to test drive.

Instant downloading -- no waiting!

When you've completed your test drives and you're ready to buy, just call our toll-free number with a credit card number or purchase order. We'll give you an access key so you can instantly download the software to your hard drive, then we'll mail you the retail package and manuals.

Free games CD!

Order your EvaluWare CD-ROM before April 30, 1995 and we'll send you a FREE CyberMart™ CD containing 50 action-packed games -- including *Critical Path*, *Microsoft Flight Simulator* and *Aces Over Europe*.

Call today 1-800-842-4669

Call now for your value-packed EvaluWare CD-ROM at the special introductory price of only \$29.95 plus shipping and handling.

**We'll refund the full purchase price of your EvaluWare CD-ROM when you order your first software package from us.*



InfoNow

1640 Range Street, Boulder, Colorado 80301 Fax: (303) 786-8473

System requirements: Windows 3.1, DOS 5 or above, CD-ROM drive, 4 MB RAM, 10 MB disk space. EvaluWare and CyberMart are trademarks of InfoNow Corporation. Windows is a trademark of Microsoft Corporation. All software titles are property of their respective owners.

Circle No. 15

Order now
and get a
FREE
games
CD!

calendar

Debi P. Mukherjee, Department of Orthopaedic Surgery, Louisiana State University Medical Center, 1501 Kings Highway, Shreveport, LA 71130-3932; 318-675-6187; fax, 318-675-6186; e-mail, dumkhe@pop3.lsumc.edu.

Conference on Computational Intelligence for Financial Engineering—CIFE (C, NN), April 9–11, Crown Plaza, New York City; Scott Mathews, 14920 24th Ave., S.E., Bothell, WA 98012–5718; 206-485-0442; fax, 714-752-7444; e-mail, 74710.2266@compuserv.com.

28th Annual Simulation Symposium (C), April 9–13, Crescent Hotel, Phoenix, Ariz.; Enrique V. Kortright, Computer Science Department, Nichols State University, Thibodaux, LA 70310; 504-448-4406; fax, -448-4927; e-mail, ek@reality.nich.edu.

First Malaysia International Conference on Electromagnetic Compati-

bility—ICEMC '95 KUL (Malaysia Section); April 11–13, Shangri-La Hotel, Kuala Lumpur; Hussein Ahmad, Universiti Teknologi Malaysia, Fakulti Kejuruteraan Elektrik, Jalan Semarak, 54100 Kuala Lumpur, Malaysia; (60+3) 290 4219; fax, (60+3) 293 4844.

Fourth International Symposium on Database Systems for Advanced Applications (C), April 11–14, National University of Singapore; Chung-Kwong Yuen, Department of IS&CS, National University of Singapore, Lower Kent Ridge 0511, Singapore; (65) 772 2831; fax, (65) 779 4580; e-mail, yuenck@iscs.mus.sg.

Applications and Science of Artificial Neural Networks VI—SPIE (NN), April 17–21, Marriott's Orlando World Center, Florida; D. Ruck, AFIT/ENG, Building 642, 2950 P St., Wright Patterson AFB, OH 45433; 513-255-6565, ext. 4285; fax, 513-476-4055; e-mail, d.ruck@ieee.org.

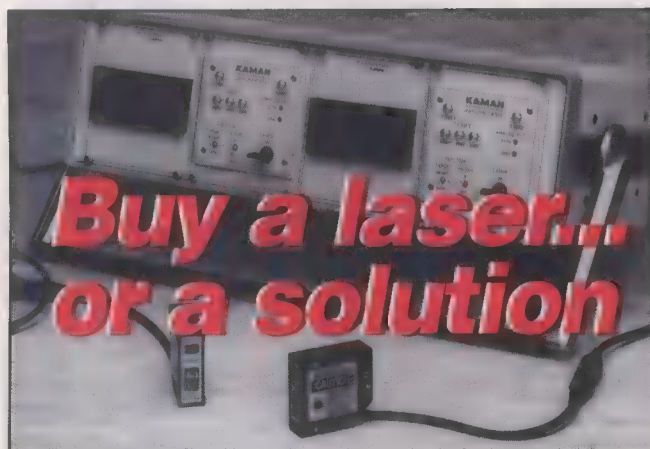
Intermag '95 (MAG), April 18–21, Marriott Rivercenter Hotel, San Antonio,

Texas; Diane Suiters, Courtesy Associates, 655 15th St., N.W., Suite 300, Washington, DC 20005; 202-639-5088; fax, 202-347-6109.

Fifth International Workshop on Network and Operating System Support for Digital Audio and Video—Nossdav '95 (COM), April 19–21, New England Center, Durham, N.H.; Thomas D. C. Little, Boston University, College of Engineering, 44 Cummington St., Boston, MA 02215; 617-353-9877; fax, 617-353-6440.

Information Theory Workshop on Information Theory, Multiple Access and Queueing (IT), April 19–21, Adam's Mark Hotel, St. Louis, Mo.; Leandros Tassioulas, Polytechnic University, 6 Metrotech Center, Brooklyn, NY 11201; 718-260-3511; fax, 718-260-3074.

Workshop on Electronic Design Processes (C, CAS), April 19–21, Breckinridge Hilton Hotel, Colorado; William J. McCalla, Cadence Design Systems, 555 River Oaks Parkway, San



EFFECTIVE POSITION MEASUREMENTS CALL FOR MORE THAN JUST MEASURING

Many companies sell lasers. Only Kaman specializes in solutions. We offer what you need: displays, serial communications, data logging, closed loop control, math functions, etc. The LTS-946 laser sensor can be a stand-alone system or integrated with our EuroRack instrumentation display and function modules. We'll work with you, recommend a system, and even supply CAD drawings. Please call us for assistance.

800-552-6267

Kaman Instrumentation, 1500 Garden of the Gods Road, Colorado Springs, CO 80907 719-599-1132, Fax 719-599-1823

KAMAN

Circle No. 27

60 MSPS 12 BIT A/D CARD

- ◆ 61 dB SNR
- ◆ 30 MSPS on 2 ch.
- ◆ Very Deep Buffers
- ◆ Up to 32 ch. Systems

Drivers in
C, Pascal,
FORTRAN,
Windows DLL,
LabVIEW,
TurboPascal,
HyperGator...

CompuScope 6012 World's Fastest 12 Bit A/D Card

CSLITE	8 bit / 40 MSPS / 16K	\$595
CS220	8 bit / 40 MSPS / 256K	\$1,995
CS250	8 bit / 100 MSPS / 32K	\$3,500
CS1012	12 bit / 20 MSPS / 512K	\$4,995
CS6012	12 bit / 60 MSPS / 512K	\$6,995

CALL 1-800-567-GAGE

Gage Applied Sciences Inc.

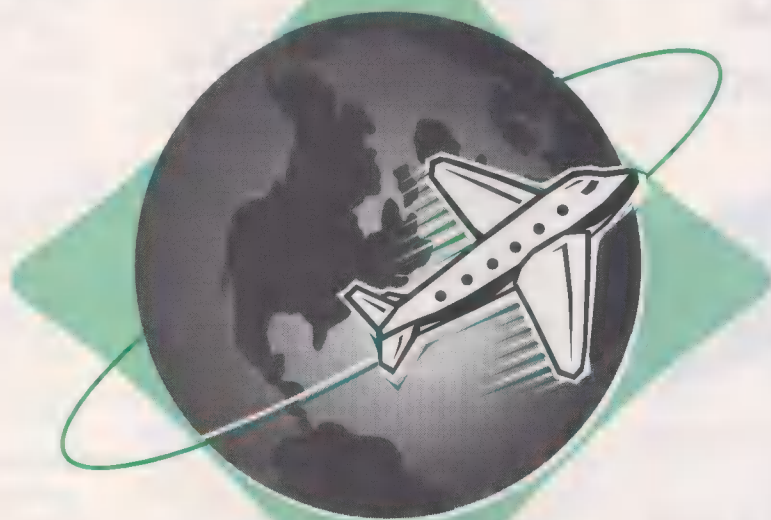
Vanden Abeele, Montreal, Quebec, Canada H4S 1S1
From outside North America, call +1-514-337-6893
Fax: (514) 337-8411, BBS: (514) 337-4317

GAGE

Circle No. 24

FOR IEEE CARDMEMBERS ONLY

The New IEEE TravelerMiles Program...



MILES AHEAD OF ANY OTHER

Introducing IEEE's New Frequent Flyer Program

*This extraordinary program will
enhance the value
of your IEEE credit card
and the benefits of your
IEEE membership.
It's the most comprehensive
frequent flyer program available.*

Fly Anytime on Most Major Airlines With No Blackout Periods

The TravelerMiles program has absolutely no blackout periods, so you can travel when you want. Mileage points will be redeemed on most major carriers including American, American West, Continental, Delta, TWA, United, Northwest (KLM), Southwest and USAir (British Airways).

Earn FREE Airline Miles When You Use Your IEEE MasterCard or VISA

You'll earn one mileage point for every dollar in purchases you charge on your IEEE endorsed credit card. Plus, you'll earn three mileage points for every dollar in finance charges you pay. Additionally, you'll get one mileage point for every dollar in balances you transfer from another credit card account at the time you enroll.

There's No Limit to the Miles You Can Earn

Your miles add up as you use your IEEE credit card and there's no limit. Unlike other airline mileage programs, once you reach 20,000 mileage points, you can start redeeming them for free airline travel.

So Great, It Will Even Pay for Itself

The enrollment fee for the TravelerMiles program is just \$75 a year. But, if you charge \$3,000 or more in travel arrangements within one year through the IEEE Travel Service using your IEEE credit card, you will be reimbursed the enrollment fee.

To enroll in IEEE TravelerMiles (if you are already an IEEE cardmember)

Call 1 800 772-2221

If you'd like to apply for the IEEE MasterCard or VISA, making you eligible for the TravelerMiles program

Call 1-800-242-9409 x58

We'll take your application right over the phone!

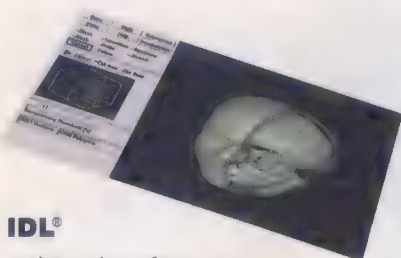
To make all your travel arrangements,
contact IEEE Travel Services

Call 1 800 TRY-IEEE

IEEE
FINANCIAL
ADVANTAGE
PROGRAM

SP395

Spend More Time Doing Science and Less Time Programming



IDL®

is the only software that allows you to program four to ten times faster* than FORTRAN or C. It seamlessly integrates all of your scientific computing needs in a single package – breathtaking 2D, & 3D graphics, powerful number crunching, flexible data I/O and more. It even includes a complete GUI toolkit for creating point and click applications. And, because IDL runs on PCs, Macs, Unix and VMS workstations you won't have to rewrite your code every time you change machines.



Join the elite group of more than 20,000 scientists around the world who are saving time and money by using IDL.

Call us for a free demo.

303-786-9900 FAX 303-786-9909

Research Systems, Inc.
2995 Wilderness Place
Boulder CO 80301

IDL



*based on a survey of IDL users

16E8

Circle No. 30

calendar

Jose, CA 95134; 408-428-5600; fax, 408-894-3479.

First International Conference on Algorithms and Architectures for Parallel Processing (Queensland, Singapore Section, et al.); April 19–22; Mayfair Crest International Hotel, Brisbane, Australia; C. W. Chan, Department of Electrical and Computer Engineering, University of Queensland, Queensland-4072, Australia; (61+7) 365 3985; fax, (61+7) 365 4999.

Fourth Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises (C); April 20–22; Coolfont Resort and Conference Center, Berkeley Springs, W. Va.; K. Joseph Cleetus, CERC, Box 6506, West Virginia University, Morgantown, WV 26506; 304-293-7226; fax, 304-293-7541; e-mail, jocle@cerc.wvu.edu.

International Workshop on Charge-Coupled Devices and Advanced Image Sensors (ED); April 20–22; Dana Point Resort, California; Eric R. Fossum, Jet Propulsion Laboratory, M/A 300–315, 4800 Oak Grove Dr., Pasadena, CA 91109; 818-393-0045; fax, 818-354-3128.

Robotics and Automation (RA); April 22–28; Minneapolis Hilton and Towers, Minnesota; Norman Caplan, National Science Foundation, BES, Room 565, 4201 Wilson Blvd., Arlington, VA 22230; 703-306-1318; fax, -306-0312; e-mail, ncaplan@note.nsf.gov.

Instrumentation and Measurement Technology Conference—IMTC '95 (IM, Boston Section); April 24–26; Westin Hotel, Waltham, Mass.; Robert Myers, Conference Coordinator, 3685 Motor Ave., Suite 240, Los Angeles, CA 90034; 310-287-1463; fax, 310-287-1851.

International Computer Performance and Dependability Symposium (C); April 24–26; University of Erlangen-Numberg, Germany; Wolfgang Hohl, Informatik III, Universität Erlangen-Numberg, Martensstrasse 3, D-91058 Erlangen, Germany; (91+31) 857 010; fax, (91+31) 393 88.

17th International Conference on Software Engineering (C); April 24–28; Westin Hotel, Seattle, Wash.; Dewayne Perry, AT&T Bell Laboratories, 600 Mountain Ave., Murray

Hill, NJ 07974; 908-582-2529; fax, 908-582-7550; e-mail, dep@research.att.com.

Technical Conference on Rubber and Plastics Industry (IA, Akron Section); April 25–26; Quaker Square Hilton, Akron, Ohio; Kenneth Kling, c/o MC2 Inc., 3201 East Royalton Rd., Broadview Heights, OH 44147; 216-526-6511; fax, 216-526-8474.

International Parallel Processing Symposium (C); April 25–28; Fess Parker's Red Lion Resort, Santa Barbara, Calif.; Viktor K. Prasanna, Department of Electrical Engineering Systems, EEB-244, University of South Carolina, Los Angeles, CA 90089–2562; 213-740-4483; fax, 213-740-4449; e-mail, prasanna@halcyon.usc.edu.

Princeton/Central Jersey Sarnoff Symposium (LEO, MTT et al.); April 28; David Sarnoff Research Center, Princeton, N.J.; Samantha Phillips, IEEE/LEOS, 445 Hoes Lane, Box 1331, Piscataway, NJ 08855–1331; 908-562-3894; fax, 908-562-8434; e-mail, s.phillips@ieee.org.

International Symposium on Circuits and Systems—IsCAS '95 (CAS); April 28–May 6; Sheraton Seattle Hotel, Washington; Meeting Management, IsCAS '95, 2603 Main St., Suite 690, Irvine, CA 92714; 800-321-6338; fax, 714-752-7444.

Rural Electric Power Conference (IA); April 30–May 2; Sheraton Music City Hotel, Nashville, Tenn.; Gregory P. Woodsmall, Northern Virginia Electric Cooperative, 5399 Wellington Rd., Box 310, Gainesville, VA 22065; 703-754-6700; fax, 703-754-6777.

13th VLSI Test Symposium (C); April 30–May 3; Princeton Marriott Hotel, New Jersey; Prab Varma, CrossCheck Technology, 2833 Junction Ave., Suite 100, San Jose, CA 95134; 408-432-9200; fax, 408-432-0907; e-mail, prab@crosscheck.com.

may

International Symposium on Electronics and the Environment (TAB); May 1–3; Hyatt Regency, Orlando, Fla.; Conference Registrar, IEEE Technical Activities, 445 Hoes Lane, Box 1331, Piscataway, NJ 08855–1331; 908-562-3878; fax, 908-981-1769; e-mail, conferenceregistrar@ieee.org.

Continued on p. 68E1

Here's How To Get The Answers.

I'd like to review my insurance coverage. Please send me information (including features, costs, eligibility, renewability, limitations and exclusions) about the following plans:

- | | |
|---|---|
| <input type="checkbox"/> Term Life | <input type="checkbox"/> Disability Income Protection |
| <input type="checkbox"/> Comprehensive HealthCare | <input type="checkbox"/> Excess Major Medical |
| <input type="checkbox"/> In-Hospital | <input type="checkbox"/> High-Limit Accident |
| <input type="checkbox"/> Long Term Care | <input type="checkbox"/> Cancer Expense Insurance |
| <input type="checkbox"/> Small Business | |

Title: ☐ Mr. ☐ Mrs. ☐ Ms. ☐ Miss

Name _____
FIRST MI LAST

DOB _____ SS# _____ Membership# _____
MO./DAY/YR.

Address _____

City _____ County _____ State _____ ZIP _____

Home Phone No. () _____ Work Phone No. () _____

3/95

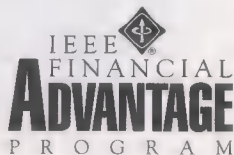
ch a rush.

the ocean
forget your
ms.

pride in
ou do.



Now Ask Yourself
If You Have The Right Insurance.



Term Life ■ Disability Income Protection
Comprehensive HealthCare ■ Excess Major Medical
In-Hospital ■ High-Limit Accident ■ Long Term Care
Cancer Expense Insurance ■ Small Business

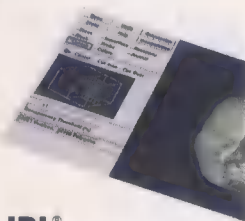
The term life, disability income protection and high-limit accident plans are underwritten by the New York Life Insurance Company, 51 Madison Avenue, New York, NY 10010.

Why bother thinking about it when there is so much around you to enjoy? Because by taking a minute to secure your life's goals, you can enjoy everything else that much more.

One benefit of IEEE membership is that shopping for insurance really does take just a few minutes. Because we've done the shopping for you. We've worked hard to get competitive group rates. We've tailored our plan to fit your lifestyle. And our insurance stays with you from job to job.

To speak with a customer service representative, call 1 800 493-IEEE (4333), or in Washington, DC (202) 457-6820, between 8:30 a.m. and 8:00 p.m. eastern time.

Spend M Time Do Science a Less Tim Program



IDL®

is the only software that allows you to process data ten times faster* than other software. It seamlessly integrates scientific computing and graphics in a single package – breathtaking 2D & 3D graphics, powerful number crunching, flexible data I/O and more. It even includes a complete GUI toolkit for creating point and click applications. And, because IDL runs on PCs, Macs, Unix and VMS workstations you won't have to rewrite your code every time you change machines.



Join the elite group of more than 20,000 scientists around the world who are saving time and money by using IDL.

Call us for a free demo.

303-786-9900 FAX 303-786-9909

Research Systems, Inc.
2995 Wilderness Place
Boulder CO 80301

IDL



*based on a survey of IDL users

BUSINESS REPLY MAIL

FIRST CLASS MAIL PERMIT NO. 8522 ALEXANDRIA, VA

POSTAGE WILL BE PAID BY ADDRESSEE

DUKE STREET PROCESSING CENTER
IEEE GROUP INSURANCE PROGRAM
1613 DUKE STREET SUITE 100
ALEXANDRIA VA 22314 9866

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES



Coupled Devices and Advanced Image Sensors (ED); April 20-22; Dana Point Resort, California; Eric R. Fossum, Jet Propulsion Laboratory, M/A 300-315, 4800 Oak Grove Dr., Pasadena, CA 91109; 818-393-0045; fax, 818-354-3128.

Robotics and Automation (RA); April 22-28; Minneapolis Hilton and Towers, Minnesota; Norman Caplan, National Science Foundation, BES, Room 565, 4201 Wilson Blvd., Arlington, VA 22230; 703-306-1318; fax, -306-0312; e-mail, ncaplan@note.nsf.gov.

Instrumentation and Measurement Technology Conference—IMTC '95 (IM, Boston Section); April 24-26; Westin Hotel, Waltham, Mass.; Robert Myers, Conference Coordinator, 3685 Motor Ave., Suite 240, Los Angeles, CA 90034; 310-287-1463; fax, 310-287-1851.

International Computer Performance and Dependability Symposium (C); April 24-26; University of Erlangen-Nürnberg, Germany; Wolfgang Hohl, Informatik III, Universität Erlangen-Nürnberg, Martensstrasse 3, D-91058 Erlangen, Germany; (91+31) 857 010; fax, (91+31) 393 88.

17th International Conference on Software Engineering (C); April 24-28; Westin Hotel, Seattle, Wash.; Dewayne Perry, AT&T Bell Laboratories, 600 Mountain Ave., Murray

908-562-3894; fax, 908-562-8434; e-mail, s.phillips@ieee.org.

International Symposium on Circuits and Systems—IsCAS '95 (CAS); April 28-May 6; Sheraton Seattle Hotel, Washington; Meeting Management, Iscas '95, 2603 Main St., Suite 690, Irvine, CA 92714; 800-321-6338; fax, 714-752-7444.

Rural Electric Power Conference (IA); April 30-May 2; Sheraton Music City Hotel, Nashville, Tenn.; Gregory P. Woodsmall, Northern Virginia Electric Cooperative, 5399 Wellington Rd., Box 310, Gainesville, VA 22065; 703-754-6700; fax, 703-754-6777.

13th VLSI Test Symposium (C); April 30-May 3; Princeton Marriott Hotel, New Jersey; Prab Varma, CrossCheck Technology, 2833 Junction Ave., Suite 100, San Jose, CA 95134; 408-432-9200; fax, 408-432-0907; e-mail, prab@crosscheck.com.

may

International Symposium on Electronics and the Environment (TAB); May 1-3; Hyatt Regency, Orlando, Fla.; Conference Registrar, IEEE Technical Activities, 445 Hoes Lane, Box 1331, Piscataway, NJ 08855-1331; 908-562-3878; fax, 908-981-1769; e-mail, conferenceregistrar@ieee.org.

Continued on p. 68E1

Ask Yourself Why

spring is such a rush.

the sound of the ocean
can make you forget your
problems.

you take pride in
what you do.



Now Ask Yourself
If You Have The Right Insurance.



Term Life • Disability Income Protection
Comprehensive HealthCare • Excess Major Medical
In-Hospital • High-Limit Accident • Long Term Care
Cancer Expense Insurance • Small Business

The term life, disability income protection and high-limit accident plans are underwritten by the New York Life Insurance Company, 51 Madison Avenue, New York, NY 10010.

Why bother thinking about it when there is so much around you to enjoy? Because by taking a minute to secure your life's goals, you can enjoy everything else that much more.

One benefit of IEEE membership is that shopping for insurance really does take just a few minutes. Because we've done the shopping for you. We've worked hard to get competitive group rates. We've tailored our plan to fit your lifestyle. And our insurance stays with you from job to job.

To speak with a customer service representative, call 1 800 493-IEEE (4333), or in Washington, DC (202) 457-6820, between 8:30 a.m. and 8:00 p.m. eastern time.

washington watch

Republicans challenge White House on science

Administration officials can expect cuts in science and technology programs, they were told by the new chairman of the House Committee on Science. "We have to get past the idea of these things as [permanently funded] government programs," said Robert S. Walker (R-Pa.) at his committee's first public hearing, held Jan. 6.

The White House Science Advisor, John Gibbons, vowed in a statement to "stand and fight" against the proposed cuts, which as outlined, he said, could cause a "wholesale, devastating retreat" in the U.S. science and technology enterprise "on which our future depends."

After testimony from the chiefs of five

key agencies, Walker urged them to find other ways of spurring research in industry, such as deregulation or tax incentives for specific technology development.

A statement by leaders in industry and academia distributed by the Council on Competitiveness noted that historically, government has given bipartisan support to science and technology, funding about half the nation's R&D. It called for the creation of tax incentives and a regulatory climate that would be more supportive of R&D.

For copies of testimonies, call the IEEE Washington office at 202-785-0017.



A new influence on R&D

A former advocate of the superconducting supercollider and still a supporter of the space station, House

Science Committee chairman Robert S. Walker (R-Pa.) said he wants to kill the Advanced Technology Program, which he called a "font of national industrial policy."

He also expects to hold hearings on the Mission to Planet Earth and the Global Warming research programs, which in his view may be supporting questionable science. He said that basic (rather than applied) research should be the focus of the National Science Foundation, which since the 1980s has sponsored a greater share of applied research.

As to a Republican proposal to eliminate Congress' Office of Technology Assessment, Walker said that he is open to the idea, but cited the value to Congress of having independent technical advice. [See "The Office of Technology Assessment: an endangered species worth saving," *IEEE Spectrum*, February 1995, pp. 13-14.] If the office is to stay, he suggest-

ONLY COOL-AMP SILVERPLATES ON THE JOB.

Cool-Amp assures cool conductivity for copper, brass, bronze contacts. Prevents power loss from oxidation.

Applies easily on-the-job.

Even outperforms electroplating in recent tests. Time proven since 1944.

CONDUCTO-LUBE. THE SILVER-BASED CONDUCTIVE LUBRICANT.

The upstart, since 1952. Developed for switches.

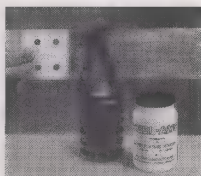
Uses continue to expand to all applications needing a conductive lubricant.

ORDER FACTORY DIRECT:

503-624-6426 or FAX 503-624-6436

Conducto-Lube

COOL-AMP



BACK BY POPULAR DEMAND, THE LATEST CONFERENCE VIDEO PROCEEDINGS IN ROBOTICS AND AUTOMATION!

1994 ROBOTICS AND AUTOMATION CONFERENCE VIDEO PROCEEDINGS

You won't want to miss this compilation videotape, which focuses on the latest information available from robotics and automation intelligence sources from around the world! This important video explains the advances that have taken place and shows the results in practice. Grouped into six categories, the 1994 video covers such topics as: Design and Mechanisms; Sensing and Inspection; Control; Mobility; Applications; and Simulation Programming and Teleoperation.

Sponsored by the 1994 IEEE International Conference on Robotics and Automation

IEEE Member Price: \$80.00

List Price: \$130.00

IEEE Order No. INTND/HV5777-PDN

ISBN (INTD) 0-7003-2252-5

IEEE Order No. (PAL) HV5785-PDN

ISBN (PAL) 0-7003-2252-3

For fastest service, call toll free (in USA)

1-800-678-IEEE

fax 1-908-981-9667;

phone 1-908-981-0060



The Institute of Electrical and Electronics Engineers, Inc.

Circle No. 32

ed that its reports be more timely and better tailored to the authorization process, according to a report by IEEE-USA lobbyist Chris Brantley.

The American Association of Engineering Societies had lobbied for a name less narrow than the House Science Committee (formerly it was the House Committee on Science, Space and Technology). Still, the four subcommittees do reflect a broader agenda: Space and Aeronautics, Basic Research, Energy and Environment, and Technology.

Walker, 54, is a former high school teacher who was first elected to Congress in 1976. In 1989 he was brought into the House Republican leadership by then Minority Whip Newt Gingrich. He also serves as vice chairman of the influential House Budget Committee.

New rules for foreign hires

Final regulations recently published by the Labor Department are likely to "strengthen protections for U.S. workers, including engineers and scientists," while preventing the "exploitation of foreign professionals," according to

the IEEE-USA.

Among the requirements are that employers tell the department how many foreign nationals they intend to hire, where and for how long the aliens are to be employed, and how much they will be paid. Greater detail on the methodology used by companies to determine the wages of foreign professionals is also required.

For more information, contact Vin O'Neill at IEEE-USA at 202-785-0017 or by Internet at v.oneill@ieee.org.

Ethics in fuzzy areas

Every researcher knows plagiarism is not good practice, but what about the sharing of research materials or fair contracts for industrial sponsorship of academic research? These and other fuzzy ethical areas are tackled in a revised guide by a committee of the National Academies of Science and Engineering and the Institute of Medicine.

So long as the core virtues of honesty, skepticism, fairness, collegiality, and openness prevail, the research enterprise will have "unparalleled productivity and creativity," states the 40-page booklet. Titled "On Being a Scientist," it is appro-

priate for engineers, too.

Copies are being distributed to graduate students free of charge. For others, the price is \$5 from the National Academy Press at 202-334-3313 or 800-624-6242.

Green aid for small firms

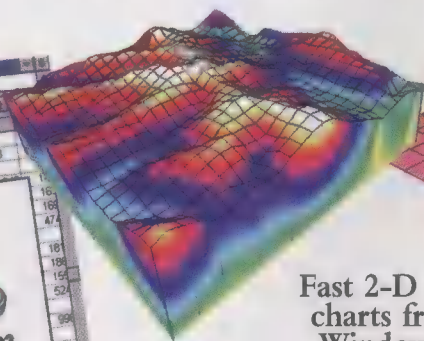
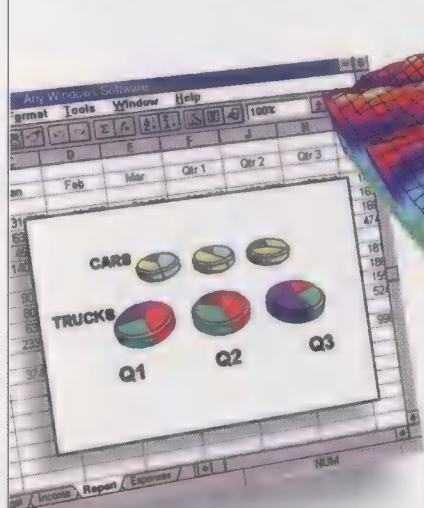
The goal of a new Commerce Department program is to help small and medium-sized U.S. manufacturers to solve environmental issues before the issues become compliance problems. There are approximately 370 000 such companies.

The program is being administered by the department's National Institute of Standards and Technology (NIST) in cooperation with the Environmental Protection Agency. Proposals are sought in three areas: integration of environmental services in manufacturing extension centers; technical assistance tools; and pilot programs for industry-specific pollution prevention.

There are currently 44 manufacturing extension centers and plans for 100 nationwide by 1997. For more information, contact NIST by phone at 301-975-5020.

JOHN A. ADAM, Washington Editor

Visualize your Excel and 1-2-3 data like never before.



Fast 2-D and 3-D charts from any Windows data.

Once again, the makers of award-winning Harvard Graphics bring you the innovative graphics software you really want. This amazingly easy to use charting tool removes the traditional boundaries faced by

spreadsheet users to offer fast, flexible charting and visual analysis of business, statistical and technical information.

Harvard ChartXL™ for Windows offers a dazzling Graph Gallery of 183 chart types, including bubble plots, error bars and 3-D contour plots. The program also provides a complete set of design tools, including drawing, rotation and 3-D perspectives.

Certified by Microsoft for full compatibility with the entire MS Office suite of software, new Harvard ChartXL is an excellent complement to any Windows package.



For more information, or to order,

**Call
1-800-336-8360
Oper. 433**

SPC SOFTWARE PUBLISHING

© 1994 Software Publishing Corporation. All rights reserved. Harvard, Harvard Graphics and the Software Publishing Corporation name and logo are registered trademarks and Harvard ChartXL is a trademark of Software Publishing Corporation. Harvard ChartXL and Harvard Graphics are products of Software Publishing Corporation and have no connection with Harvard University. SPC acknowledges the trademarks, and the rights of trademark owners, referred herein.

Circle No. 28

recent books

Continued from p. 14

PowerBuilder: Building Client Server Applications. Mahler, Paul, Prentice Hall, Englewood Cliffs, N.J., 1995, 440 pp., \$34.95.

Simplified Design of Switching Power Supplies. Lenk, John D., Butterworth-Heinemann, Woburn, Mass., 1995, 224 pp., \$39.95.

Progress in Simulation, Vol. 2. Eds. Zobrist, George W., and Leonard, James V., Ablex Publishing, Norwood, N.J., 1994, 412 pp., \$65.

Controlling Technology: Ethics and the Responsible Engineer, 2nd edition. Unger, Stephen H., John Wiley & Sons, Somerset, N.J., 1994, 353 pp., \$34.95.

The UNIX Philosophy. Gancarz, Mike, Butterworth-Heinemann, Woburn, Mass., 1995, 151 pp., \$19.95.

Developing Microsoft Excel 5 Sol-

utions. Wells, Eric, Microsoft Press, Redmond, Wash., 1995, 712 pp., \$39.95.

Video Compression for Multimedia. Ozer, Jan, Academic Press, New York, 1995, 387 pp., \$39.95.

The New Rules of the Job Search Game: Why Today's Managers Hire...and Why They Don't. Larson, Jackie, and Comstock, Cheri, Adams Publishing, Holbrook, Mass., 1994, 254 pp., \$10.

Circuits of the Mind. Valiant, Leslie G., Oxford University Press, New York, 1994, 237 pp., \$49.95.

AIX RS/6000 System and Administration Guide. DeRoest, James W., McGraw-Hill, New York, 1995, 464 pp., \$39.95.

Field Programmable Gate Arrays: Reconfigurable Logic for Rapid Prototyping and Implementation of Digital Systems. Oldfield, John R., and Dorf, Richard C., John Wiley & Sons, New York, 1995, 327 pp., \$59.95.

The ISDN Literacy Book. Hopkins, Gerald L., Addison-Wesley, New York, 1995, 367 pp., \$34.50.

Nikola Tesla On His Work With Alternating Currents and Their Application to Wireless Telegraphy, Telephony, and Transmission of Power. Ed. Anderson, Leland I., Twenty First Century Books, Breckenridge, Colo., 1994, 237 pp., \$40.

Using Digital Video. Luther, Arch C., Academic Press, New York, 1995, 297 pp., \$34.95.

Text Algorithms. Crochemore, Maxime, and Rytter, Wojciech, Oxford University Press, New York, 1994, 412 pp., \$95.

The Discipline of Market Leaders: Choose Your Customers, Narrow Your Focus, Dominate Your Market. Treacy, Michael, and Wiersema, Fred, Addison-Wesley, New York, 1995, 208 pp., \$25.

Nikola Tesla: Lecture Before the New York Academy of Sciences—April 6, 1897. Ed. Anderson, Leland I., Twenty

Meet the next generation of math software ...

New Macsyma® 2.0



Tops in Applied Math Power

- Best for basic algebra and calculus
- **NEW** More symbolic-numerical linear algebra than any other product
- Best for ODEs and **NEW** for PDEs
- Companion PDEase™ solve PDEs by finite elements with "no mesh, no fuss"

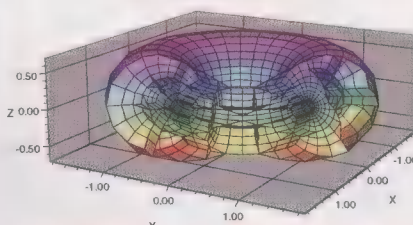
Tops in Ease of Use

- **Unique:** 800 executable demos and examples launched from the menus
- **Unique:** 600 fill-in templates to help you compose your own commands
- 2,000 hypertext descriptions
- Best organized, context-sensitive menus and toolbars.

Call 1-800-macsyma for a PC demo or workstation trial.

‡ Notebooks and some graphics features not now on workstations. Macsyma is a registered trademark of Macsyma Inc. PDEase is a trademark of SPDE, Inc.

Cut-Away of Toroidal Coordinates



• "...Macsyma is now the leader in the mathematical program marketplace."

- PC Magazine (US)

• "... numerical commands are nearly as numerous as in specialized number-crunching programs ... In its symbolic capabilities, Macsyma is the heavy artillery ... remarkably easy to use. ... Users with heavy math needs should insist on Macsyma."

- IEEE Spectrum (US)

• "Its enormity never compromises its ease of use."

- Personal Computer World (UK)

NEW Notebook Interface‡

- **Unique:** Math display methods make large math expressions readable
- **Unique:** Edit completed graphics right in Macsyma notebooks.
- Best formatted text: single character formatting, paragraph formatting

NEW Scientific Graphics

- **Unique:** Edit 200 attributes of a typical 3D plot with 5 custom dialogs
- **Unique:** Mouse query for position 3D
- Publication-quality labeling
- IHS/RGB color models, lighting
- Viewpoint, roll, truck, zoom, clipping
- Camera / data animation

Macsyma Inc. tel: 617-646-4550
20 Academy Street fax: 617-646-3161
Arlington, MA 02174 free: 800-macsyma
U.S.A. info@macsyma.com

Circle No. 36

AS THE TWENTY-FIRST
CENTURY
APPROACHES, THE
TECHNOLOGIES OF
ELECTRICAL
ENGINEERING,
ELECTRONICS, AND
COMPUTING ARE
REDEFINING AND
REDESIGNING OUR
WORLD. THE 92
QUALITY JOURNALS
AND MAGAZINES IN
IEEE'S PACKAGE IS
THE CORE COLLECTION
IN THESE FIELDS FOR
LIBRARIES. AS CERTI-
FIED BY THE 1992
JOURNAL CITATION
REPORT OF ISI (THE
MOST RECENT EDITION)
IEEE PERIODICALS
REMAIN THE MOST-
CITED PERIODICALS
IN THEIR RESPECTIVE
FIELDS.

INTRODUCING THE 1995 IEEE ALL-SOCIETY PERIODICALS PACKAGE

WHERE TECHNOLOGY IS EXPLODING TO SERVE MANKIND

Our All-Society Periodicals Package Brings You These Major Benefits:

► CORE COLLECTION IN THE FIELD

IEEE periodicals cover every aspect of electrical engineering, electronics and computing completely and authoritatively. By subscribing to the All-Society Periodicals Package, you'll maintain the core collection of your library by receiving the major work in the field.

► GET OVER 1/3 FREE

The 1995 Package costs \$11,995 for our 92 top periodicals. If you subscribed to each one individually, you'd pay \$20,106. That's a savings of \$8,111 or over one-third!

► FREE 1995 INDEX

With our All-Society Package you'll get the new 1995 two-volume *Index to IEEE Publications* — a value of over \$500 — free.



SUBSCRIBE TO THE
IEEE PACKAGE...

AND GET OVER
1/3 OF THEM FREE!

For a free brochure or to order
call toll-free in the U.S.:

1-800-701-IEEE

(1-908-981-0060 outside the U.S.)

or fax:

1-908-981-9667

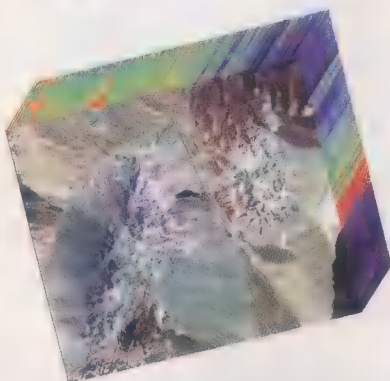


THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.
445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331 U.S.A.

ENVI Brings Remote Sensing Imagery Down to Earth

The most affordable,
powerful, and easy-to-
use image processing
software available!

ENVI is the advanced
application that lets you
quickly analyze and visualize
your remote sensing imagery;
even hyperspectral AVIRIS
and spectral libraries!



No matter what your data
format, you can do your image
processing without having to
write code. Or use ENVI's
built-in tools to write custom
functions for specialized
image analysis.

And you have the freedom to
use ENVI anywhere...it runs
the same on PCs, Macs, and
Unix & VMS workstations.

Bring *your* image processing
down-to-earth. Call or
E-mail us today to qualify for
a free demo.

303-786-9900

E-mail: envi@rsinc.com

Research Systems, Inc.
2995 Wilderness Place
Boulder CO 80301



recent books

First Century Books, Breckenridge,
Colo., 1994, 122 pp., \$21.95 (hard-
cover), \$12.95 (paperback).

Epitaxial Microstructures. Ed. Gossard,
Arthur C., Academic Press, New York,
1994, 440 pp., \$119.

A Discipline for Software Engineering.
Humphrey, Watts S., Addison-Wesley,
New York, 1995, 789 pp., \$47.50.

**ATM Systems Design: The Hitch-
Hiker's Guide.** Rahman, Mohammad,
Dallas Engineers, Dallas, 1994, 212
pp., \$60 (hardcover), \$40 (paperback).

**The Particle Garden: Our Universe as
Understood by Particle Physicists.**
Kane, Gordon, Addison-Wesley, New
York, 1995, 224 pp., \$22.

**Building a Successful Board-Test Strat-
egy.** Scheiber, Stephen F., Butterworth-
Heinemann, Boston, 1995, 286 pp.,
\$44.95.

The Product Development Challenge.
Ed. Clark, Kim B., and Wheelwright, Steven
C., Harvard Business School Press,
New York, 1995, 448 pp., \$32.50.

**The Sand Dollar and the Slide Rule:
Drawing Blueprints from Nature.**
Willis, Delta, Addison-Wesley, New
York, 1995, 288 pp., \$23.

Broadband Patch Antennas. Zurcher,
Jean-Francois, and Gardiol, Fred E., Artech
House, Boston, 1995, 211 pp., \$69.

**Every Manager's Guide to Information
Technology: A Glossary of Key
Terms & Concepts for Today's
Business Leader.** Keen, Peter G.W.,
Harvard Business School Press, New
York, 1995, 304 pp., \$18.95.

**Phase Transformations and Ablation
in Laser-Treated Solids.** Sobol, Emil
N., John Wiley & Sons, New York,
1995, 332 pp., \$59.95.

The Future of Software. Ed. Leebaert,
Derek, MIT Press, Cambridge, Mass.,
1995, 300 pp., \$24.95.

**High-Power Microwave Systems and
Effects.** Taylor, Clayborne D., and Giri,
D.V., Taylor & Francis, Bristol, Pa.,
1994, 203 pp., \$59.50.

**Quality Planning, Control, and
Improvement in Research and
Development.** Ed. Roberts, George W.,

Marcel Dekker, New York, 1995, 384
pp., \$99.75.

**Thinking in Complexity: The Com-
plex Dynamics of Matter, Mind,
and Mankind.** Mainzer, Klaus, Spring-
er-Verlag, New York, 1994, 329 pp.,
\$34.50.

**Personal Communication Systems and
Technologies.** Ed. Gardiner, John, and
West, Barry, Artech House, Boston,
1995, 242 pp., \$59.

**Werner von Siemens, Inventor and In-
ternational Entrepreneur.** Feldenkirchen,
Wilfried, Ohio State University Press,
Columbus, Ohio, 1994, 206 pp., \$19.95
(hardcover), \$12.50 (paperback).

Manufacturing Renaissance. Eds.
Pisano, Gary P., and Hayes, Robert H.,
Harvard Business School Press, New
York, 1995, 352 pp., \$29.95.

Electronic Mail. Palme, Jacob, Artech
House, Boston, 1995, 274 pp., \$54.

Handbook of Electric Motors. Ed.
Engelmann, Richard H., and Middendorf,
William H., Marcel Dekker, New York,
1995, 832 pp., \$150.

Animation Techniques in Win32.
Thompson, Nigel, Microsoft Press,
Redmond, Wash., 1995, 288 pp., \$39.95.

Introducing Microsoft Windows 95.
Microsoft Corp., Microsoft Press,
Redmond, Wash., 1995, 368 pp., \$12.95.

**Computer Visualization: Graphics
Techniques for Scientific and
Engineering Analysis.** Gallagher,
Richard S., CRC Press, Boca Raton,
Fla., 1995, 312 pp., \$69.95.

**VLSI for Neural Networks and Ar-
tificial Intelligence.** Eds. Delgado-Frias,
Jose G., and Moore, William R., Plenum
Press, New York, 1994, 320 pp., \$85.

**Intermediate Classical Dynamics with
Applications to Beam Physics.**
Michelotti, Leo, John Wiley & Sons, New
York, 1995, 340 pp., \$59.95.

**Writing Bug-Free C Code for
Windows? A Programming Style
that Automatically Detects Bugs in
C Code.** Jongerius, Jerry, Prentice Hall,
Englewood Cliffs, NJ., 1995, 218 pp., \$29.

**Handbook of Materials and Tech-
niques for Vacuum Devices.** Kohn,

Continued on p. 66TE

EV watch

Government report misrepresents EVs

In response to a request from the Committee on Science, Space, and Technology of the U.S. House of Representatives, the General Accounting Office (GAO) has conducted a study of development and commercialization programs for electric vehicles in the United States and elsewhere. In December, it presented its findings in a report titled *Electric vehicles: Likely consequences of U.S. and other nations' programs and policies*. (For a free copy, call the GAO at 202-512-6000; fax, 301-258-4066.)

The report examines current barriers to the widespread use of electric vehicles and reviews the EV policies and programs of seven countries, as well as the national and regional effects of EVs on economy, energy, and the environment.

It makes some useful observations. In particular, its analysis of the potential market for EVs contrasts the rather optimistic figures based on what is technically possible with the less promising results obtained on the basis of consumer-preference studies. The report concluded that neither approach by itself provided much useful information.

Unfortunately, the document is also so full of bias and outright errors as to make EVs appear much less attractive than they actually are. For example, in discussing the environmental effects of EVs in New York City, the report states that, in the year 2000, the utility that serves the city, Consolidated Edison Co. of New York Inc., plans to obtain more than half of its off-peak electricity from "highly polluting coal and oil."

That is just not the case, according to Martin Gitten, Con Edison's assistant director of public information: in 1993, the company got about 10 percent of its electricity from coal (the 1994 figures are as yet not available), and it has been forbidden by law since 1973 to burn coal at any of its own plants. Furthermore, he told *IEEE Spectrum*, the company is restricted to burning only low-sulfur oil (oil containing less than 0.3 percent sulfur) and today burns about half as much as it did in 1990, as it switches increasingly to natural gas.

In addition, the GAO report states that "...as of 1990, Denver, New York, and Los Angeles used coal as their primary high-demand off-peak fuel source." Ignoring the question of how something can be both "high-demand" and "off-peak," the fact is

that, in recent years, including 1990, Con Edison has derived less than 10 percent of its electricity from coal. Moreover, none of that coal was burned in densely populated New York City itself.

In a review of the report, included in an appendix, the Department of Energy has several criticisms to make. One of special interest was that the report's findings on sulfur dioxide and nitrogen oxide emissions associated with EVs do not take into account the expected impact of the Clean Air Act Amendments of 1990. The DOE said, in part, "The electric utility industry is required by the Clean Air Act Amendments to make significant reductions in emissions of oxides of nitrogen and sulfur. Specifically, sulfur oxide emissions are capped. Thus, the electric utility industry will not be allowed to increase emissions of sulfur oxides in supplying additional energy for electric vehicles."

The GAO's reaction to that observation was to point out that "...costs will increase if additional emissions must be monitored and controlled at the power plant." True, but is that a reason to ignore the law and misrepresent the facts?

The GAO went on to state: "Moreover, other nations we reviewed do not all have air quality restrictions as stringent as those in the United States. Thus, the introduction of electric vehicles in these nations could contribute to increased global emissions of nitrogen oxides and sulfur dioxide." Again, is this a reason to ignore pollution-reduction efforts within the United States?

The report tries hard to make EVs appear as outrageously expensive and as unsafe as it possibly could. In particular, it exaggerates the potential for disaster of sodium-sulfur batteries, ignoring the numerous safety features designed into them. Those features have allowed the batteries to pass without problem such demanding tests as impalement on an upended steel beam and being sliced in half by a guillotine-like device.

What is most disturbing about *Electric vehicles*, however, is not so much the factual errors, since anyone may make a mistake or two. Rather, it is the purposefully anti-EV propagandist tone—note, for instance, the application of a phrase like "highly polluting coal and oil" to rather clean 0.3-percent oil. The authors were clearly seeking to taint clean oil with the sooty image of an old coal-fired plant. This is not what we expect from a supposedly impartial Government agency.

12th International EV Symposium is largest ever

The 12th International Electric Vehicle Symposium and Electric Vehicle Exposition held this past Dec. 3–7 in Anaheim, Calif., was by far the largest in the meeting's 25-year history. According to the Electric Vehicle Association of the Americas (EVAA), under whose auspices the event was presented, it attracted more than 1600 members of the lay public in addition to 1305 registrants and over 200 journalists.

The growth in attendance at the meeting confirms what most of us knew already: that interest in EVs is on the rise. Beyond that, according to Victor Wouk, a consultant to EV Watch and one of the few attendees at EVS-12 who was also present at EVS-1 in 1969, it also served to illustrate another fact—that, in his words, "At long last reliable EVs are available and may be purchased with confidence." In the early days, he said, the cars were built by people perhaps best described as enthusiasts. Today, they are designed by competent engineers. The only questions that remain, he opined, are "Will they sell?" and "Will they satisfy their purchasers?"

In addition to the usual static exhibits, EVS-12 featured more than a dozen EVs on which visitors could take rides in the extensive Disneyland parking lot. It also boasted more than 200 papers on political, environmental, and economic issues, as well as on purely technical topics.

The symposium and exhibition is a biannual event. EVS-11 was held in 1992 in Florence, Italy. The next one, EVS-13, will be held in Osaka, Japan, Oct. 13–16, 1996, under the auspices of the Japan Electric Vehicle Association and the Electric Vehicle Association Asia-Pacific.

As good as Green Stamps

While some people—the folks at the General Accounting Office, for example—may enjoy putting down electric vehicles, there are others who regard them as desirable enough to be used as deal sweeteners. To be specific, the New York Power Authority included 10 electric cars in the package of goodies it offered Westchester County to nail down a 10-year deal under which power for county buildings will be purchased from the authority.

MICHAEL J. RIEZENMAN, Editor
VICTOR WOUK, VICTOR WOUK
ASSOCIATES, Consultant

program notes

Look the GIF horse in the mouth

JOHN R. HINES

When CompuServe Inc. threw open its Graphical Interchange Format (GIF) to the computing public, the reasonable expectation was that, by promoting the use of graphics in worldwide computer networks, the Columbus, Ohio, company would secure its position as a prime on-ramp to the Information Highway. Instead, it may have inadvertently turned GIF into a dead horse.

The format's excellence at compacting high-resolution graphical images has won the acceptance of Internet users and vendors alike, who routinely upload, store, and download GIF files. Since its debut in 1987, hundreds of thousands of GIF files have been stored in CompuServe's Graphics Forums and at Internet sites around the globe. This popularity stems from GIF's ability to store images in a lossless but compact format, so they typically occupy half the disk space needed by non-compressed formats like Hewlett-Packard Graphics Language (HPGL) and Encapsulated PostScript (EPS).

GIF derives its compression prowess from Lempel-Ziv-Welch (LZW) technology, which, unbeknownst to GIF users, was patented in 1985 by Unisys Corp., Blue Bell, Pa. Over the years since then, Unisys had licensed LZW to modem manufacturers for data compression, but it was not until January 1993 that the main-frame supplier-turned-seller of management information services told CompuServe that it would have to buy a license for its use of LZW and pay royalties on all code creating GIF format files.

In June 1994 CompuServe finally acquiesced and bought a license from Unisys. Then, in December, CompuServe informed developers of applications that employ GIF coding that they, too, had to obtain LZW licenses and pay royalties. The public outcry, as seen in Internet forum magazines, was swift.

Unisys denied any responsibility for CompuServe's decision to get developers of GIF-based software involved with licenses or royalties. "Unisys did not require CompuServe to pass on any fee to its sublicensees or end users," proclaimed a January press release, adding that, "Such a decision, and the content and timing of CompuServe's advisory, was at their discretion." The same press release stated

that "Unisys does not require licensing, or fees to be paid, for non-commercial, non-profit GIF-based applications, including those for use on the on-line services." Besides not requiring royalties for such so-called freeware, the company has said it will not ask for royalties on commercial software developed before February 1995, so that there is no reason for software developers to rush to make product changes to products already released.

Rather than pay Unisys its 1 percent royalty, though, the major vendors of graphics software have for the most part announced plans to drop GIF. Graphics programs typically support five to 10 different graphical file formats. If program developers had to cough up a 1 percent royalty on each of them, they would be handing 5-10 percent of receipts—their entire profits, in some cases—to the format developers.

The leaders' action makes GIF a dead end for smaller commercial developers. Even freeware developers should plan to eliminate GIF viewers and images from new releases because the confused legal situation surrounding GIF puts anyone involved with it at risk of a nuisance lawsuit.

For developers, the most interesting question is which format to use instead. One worth watching is the fledgling Joint Photographic Experts Group (JPEG) file format, which crops up with increasing regularity on the World Wide Web. Although the JPEG format uses a lossy compression algorithm, it can produce very small files that are just the thing for reducing file transmission costs by an order of magnitude.

Software on the air

The wide availability of high-quality training on topics related to Unix is one reason why the operating system and its associated protocol, TCP/IP, have dominated high-end computing. For example, Sun Microsystems invests heavily in Unix and TCP/IP courses supplied by National Technology University (NTU) in Fort Collins, Colo. NTU is a consortium of universities that offers courses covering a broad range of technical topics. It distributes both continuing education courses and university degree courses on videotape or in real time by satellite.

Now Microsoft Corp. has decided to air courses over its own satellite network, Microsoft TV (MSTV). MSTV broadcasts directly to developers and end users at sites with satellite antennas. Anyone without

access to an antenna may view the courses at a local Microsoft Solution Provider.

One- or two-hour courses on Microsoft software are initially to be available once a week, on Tuesdays or Thursdays, at 8 a.m. PST. The spring 1995 courses focus on Windows 95 and on client-server topics from the Internet to the Microsoft BackOffice; training on other products is to be offered as demand increases. Microsoft has also announced that PCTV will distribute its courses through the Mind Extension University channel on its cable subsidiary, the Jones Computer Network.

NTU courses typically cost US \$20-\$40 per hour per individual, but Microsoft TV courses are free, although users are required to obtain a site license before videotaping courses. Contact: NTU, 700 Centre Ave., Fort Collins, CO 80526, 303-495-6421, or **circle 115**; MSTV at 800-597-3200, or **circle 116**.

And so it goes—NOT

Those who have reviewed IBM's OS/2 Warp in glowing terms may have overlooked some installation problems. I ran into them after upgrading my home and work computers.

The beta versions of Warp installed correctly from floppies on my old ISA bus computers. But after I installed VESA Local Bus motherboards and CD ROMs, the production version of Warp would not install from CD ROM on either machine. At random points during the installation, I got the message "Device C: not available."

The problem is clearly an interaction between Warp, my Adaptec controller, my Maxtor drive, and my Texel CD ROM. Unfortunately, all three hardware vendors have denied all knowledge of Warp, leaving IBM Tech Support and me to solve the problem by ourselves. Tech Support has offered several suggestions, but so far none has eliminated the "not available" message.

Warp is a great operating system for totally brand-name computers. Whether it's also great for no-name computers with mix-and-match components has still to be determined.

Contributor John R. Hines is a silicon sensor engineer at Honeywell Inc.'s Micro Switch Division, Richardson, Texas.

Consultants: Bruce Mather, *Phototelesis Corp.*; Shari L. Pfleeger, *Systems/Software Inc.*



Here's our dilemma. If we tell you that the Microsoft® FORTRAN PowerStation family of

TAKE IT

32-bit development systems gives you the same level of performance on a high-end PC that you've come to expect from a UNIX™

FOR A

workstation, you might not believe it. You could, in fact, be skeptical when we say it's optimized to give you full

2,500 RPM SPIN

32-bit power on multiple platforms such as MS-DOS®, Windows® and Windows NT® operating systems. Even the fact that the

AND

Microsoft IMSL libraries are identical to workstation or mainframe versions but are only a fraction of their cost may not

PLEASE

fully convince you. Or that FORTRAN PowerStation makes porting existing code to PC platforms easy and facilitates

FEEL

programming thanks to an environment that lets you take full advantage of the Windows GUI. Let's face it, the only thing that's

FREE TO

sure to convince you about FORTRAN PowerStation is FORTRAN PowerStation. Which is why we're offering you the chance to

KICK THE

best drive it absolutely free. Just fax or mail in the attached coupon, or e-mail us at fortran@microsoft.com. But act fast, because

COMPILERS.

supplies are limited. And like any test drive, we ask that you observe the speed limit. So please try to keep it under 3,000.

Microsoft

"WHERE DO YOU WANT TO GO TODAY?"

FAX BACK (206) 936-7329 ATT: MICROSOFT FORTRAN

(or if you prefer, mail to Microsoft FORTRAN, 1 Microsoft Way, Redmond, WA 98052-6399.)

Before you take the FREE FORTRAN PowerStation Test Drive, there's something you should know. You don't need a license, but you do need a PC running Microsoft Windows version 3.1 or later. And you do need to hurry, because these kits are going fast.

NAME _____ JOB TITLE _____
PHONE _____ FAX _____ INTERNET ID _____
COMPANY NAME _____
COMPANY ADDRESS _____
CITY _____ STATE _____ ZIP _____



reflections

Surfing the net

EVERY TIME I TURN ON THE TELEVISION SET these days, I see some handsome actor in a commercial enthusing over the joys of "surfing the net." Of course, the actors look clueless, but the more troubling aspect is this sudden, overwhelming publicity for what used to be the private domain of technophiles. Perhaps it is time for me to move on to some preoccupation other than netsurfing. I am reminded of the wisdom in the old Yogi Berra quotation about the restaurant: "Nobody goes there anymore; it's too crowded."

I'm sure there are more important things for me to be doing. Get a life, as they say. There are books to read, places to travel to, and chores to do—things like that. But even in contemplating this real life, I sense an impending, ominous deprivation. I need the prickly salt wind in my face, the bubbling cushion of the sea beneath, and the powerful surge of the curling wave carrying me forward toward the very brink of stability. Oh, I need to be back at my keyboard!

I wasn't always an addict. Once I was an ordinary person, leading the clean and simple life. Occasionally I even did my duty as a citizen and watched television. I know this will be hard for younger readers to believe, but there was a time when there were only three TV channels. To change channels, you actually had to stand up and walk across the room. I didn't do that often, partly out of inertia, but also because I suffered under the delusion that you were supposed to watch the shows. I just didn't know any better.

I well remember my first remote controller, which was part of a beloved, now deceased, Heathkit TV set. A small, clever convenience, I thought. Once again the great idea swept by me unheeded. I should have heard the distant pounding of the approaching surf. I should have felt the first tremor of a sea breeze. But I held greatness in my hand and knew it not.

At first I used the remote awkwardly. Learning these skills as an adult is difficult. I would make the novice's mistake of tarrying too long on one channel. The world was a static place, and the breathtaking idea of 500 channels had yet to be conceived. Things were basically boring.

Now with Internet, the world sizzles with excitement and purpose. Who needs 500 channels when the galaxy itself beckons? The phosphors on my CRT display have a pinkish cast—due, I believe, to the red shift of the expanding informational universe just beyond the serial connection of my yearning PC. The picture on my screen has a slight jitter, no doubt because of the instability of the whole web infrastructure that envelops the microscopic me.

After all, looking at the display on my PC is like an astronomer's looking back in time with a powerful telescope. Whatever source emitted the information currently displayed on my screen probably changed many long microseconds ago. I may

well be looking at the dying light of an information dwarf. It doesn't matter; whatever this is, I won't tarry.

The World Wide Web and versions of Mosaic have elevated surfing to a new level. I'm excited about having multimedia on my PC. I show it to my computerphobic friends. "Look!" I exclaim. "It talks! It moves!"

They, however, must have a different frame of reference. They look at the small, low-resolution, quicktime movies with a frown. "You watch this stuff?" they ask.

I feel that the multimedia miracle is underappreciated. "Well, not really," I say apologetically. Anyway, I haven't time to study it. I must be on my way. I have to ride the surf back to the shore. Then I have to paddle out to sea. Then I have to ride the surf back to shore. Motion is everything. If you stop, you sink.

I show my friends the museums and galleries on-line, the exhibits from the Library of Congress, the journals and magazines experimenting with electronic publication. They seem disoriented by the long waits for access, followed by the milliseconds of observation I give to the retrieved results. But I have to move along. Nevertheless, I do have sympathy for their frustration—watching someone else steer is no fun.

I explain about the ten thousand discussion groups. "You mean *anyone* can post messages and replies?" they ask with a shade greater interest. I hate to dampen their new-found enthusiasm.

But I explain that that is exactly the problem. The voices that dominate the discussion are those that choose to speak the most often, not those with the most to contribute. In any case, I shrug, it really doesn't matter in an expanding universe.

Tomorrow there will be several dozen new discussion groups not yet saturated with trivia.

Continuous expansion is a necessary concept in this virtual universe.

I show my friends the services and mail-order catalogs on-line. "How do you know where to go?" they ask.

"There is no *where* there," I try to explain.

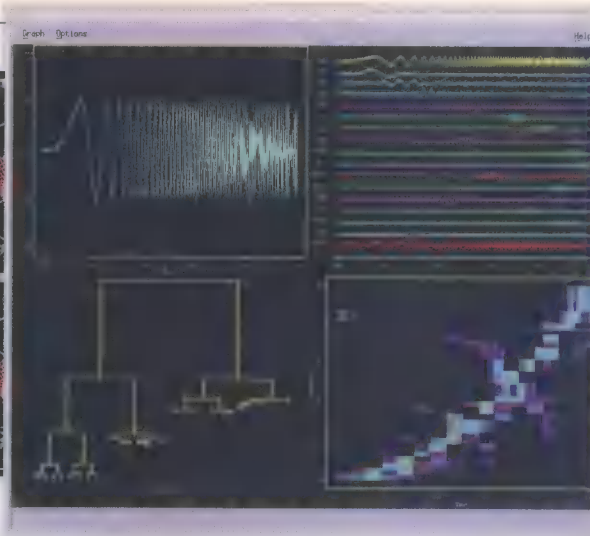
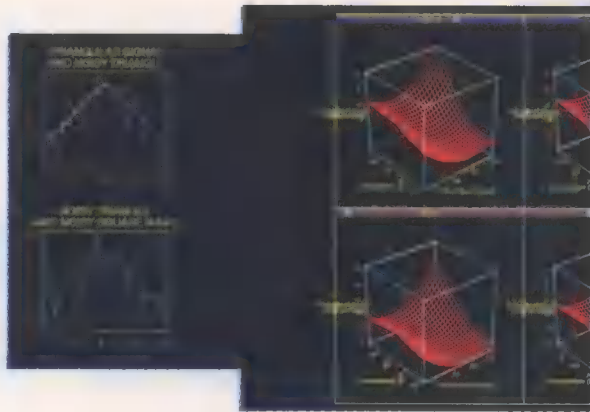
"But how do you know which on-line stores to choose, out of so many? What differentiates one from another?"

My patience is exhausted. So many questions, so few answers. Tomorrow it will be different anyway. This is a frontier society, without geographic boundaries, without laws or established customs. There is a special feel to it of exploration and freedom. And if you put your ear to the ground, you can hear the approaching hoofbeats. The settlers are coming, millions upon millions of them—and things will never be the same.

I'd like to say more about this, but I have to run. Gotta keep moving.

ROBERT W. LUCKY





NEW S + WAVELETS TOOL KIT

"Wavelets is one of the most significant advances in applied mathematics in the past decade."

Efficiently analyze signals and images at different scales to clearly reveal features overlooked with Fourier transforms.

Perform significantly better signal estimation and extraction in noisy environments than with classical methods, especially for "non-smooth" signals with jumps or spikes.

Gain an advantage in data compression by storing the essential information from large data sets, such as medical or remote sensed imagery, in a substantially smaller space.

Take Control with S-PLUS.

Gain the freedom to extract more from your data.

S-PLUS delivers the complete control you need. It gives you a comprehensive, extensible environment combining an object-oriented programming language, over 1,650 advanced and classical technical functions, and integrated visualization tools. You have the unlimited freedom to explore, analyze and model your scientific and technical data the way you see best.

OBJECT-ORIENTED programming language provides total flexibility.

- Classes and inheritance • Generic functions and methods
- Intelligent data object structures • Prototype, model and predict • Extensible, customizable functions.

Over 1,650 technical functions and high-performance mathematics allow penetrating exploration.

- Time series • Signal analysis
- Spectral analysis • Tree pattern recognizers
- Eigenanalysis • Adaptive curve fitting
- Local polynomial surface fitting • Equation solving • Supports higher dimensional arrays.

Modern, robust statistical methods for better model fit.

- Linear/non-linear least squares
- Robust model fitting • Non-parametric/non-linear model fitting.

Integrated visualization provides deep insight into multi-dimensional data.

- Dynamic brush

- and spin graphics • Trellis display graphics
- 2D and 3D graphics.

S-PLUS is the result of development and continuing research at AT&T Bell Labs, the premier organization in the world today for advancement of object-oriented data languages and modern data analysis methodologies.

So whether you are prototyping a signal processing application, developing new algorithms, performing in-depth time series analysis, or building a statistical model, S-PLUS gives you the total freedom to take control... Meet your exact requirements... And extract more meaning from your data for better results.

Operating Systems

S-PLUS is an advanced technical analysis and computing environment for MS Windows and UNIX platforms.

Call Now and Receive Three FREE Technical Papers

- *An S-PLUS Technical Overview for Engineers and Scientists* by R. Douglas Martin and John Minardi
- *Applying an Object-Oriented Paradigm to Statistical Computing* by Martin Hintz
- *Nonlinear Wavelet Methods for Recovery of Signals, Densities, and Spectra from Indirect and Noisy Data* by David L. Donoho.

Learn how the experts control data for better visualization, analysis, and modeling.

NORTH AMERICA

Phone: 1-800-569-0123
FAX: 206-283-7583
e-mail: mktg@statsci.com

INTERNATIONAL

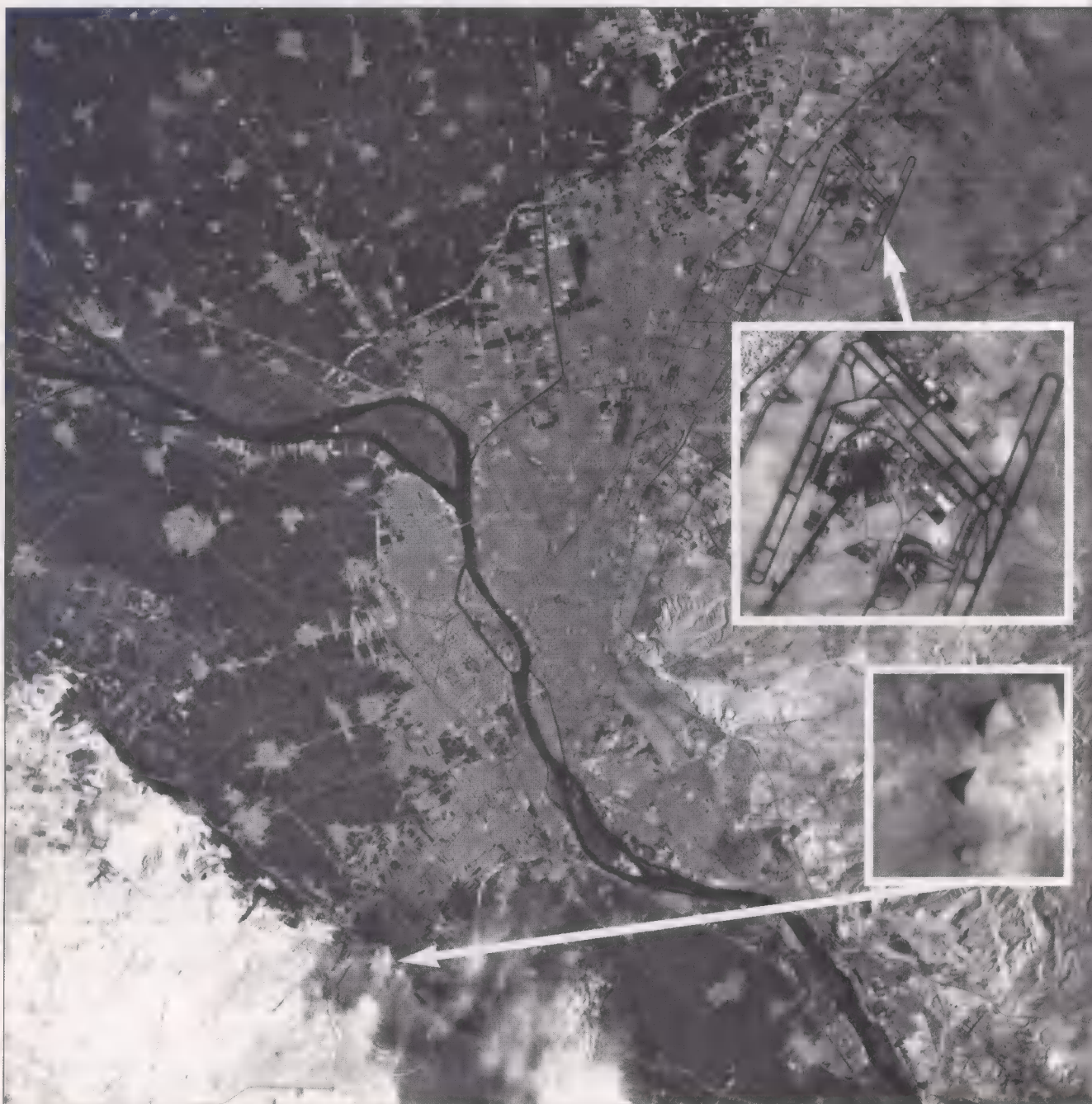
Phone: +44 1506 401538
FAX: +44 1506 465500
e-mail: intl@statsci.com

StatSci

A DIVISION OF
MathSoft
Σ + √ - = × ÷ + 8

StatSci A Division of MathSoft
1700 Westlake Ave N, Suite 500
Seattle, WA 98109 USA
Phone: 206-283-8802

REMOTE



SOVIET FORMER SPUTNIK/EARTH OBSERVATION SATELLITE CO. (EOSAT)

Technology for manipulating satellite imagery is now to hand—but coping with terabytes of data from future systems will up the computer ante yet again

SENSING

FULFILLING MORE THAN TWO DECADES OF promises, data from satellite and airborne sensors are at last being applied to all manner of earthly concerns. The delay was due not to a lack of ideas for the data's use, but to a dearth of technology users needed to bend the raw data to their will.

"Remote sensing is an *information* technology, not an aerospace technology," declared Donn C. Walklet, president and chief executive officer of TerraNova International in Los Altos, Calif. Whereas 6 MB of memory might store the information contained in a map, he noted, 200–300 MB is needed for the digital data in a single scene obtained with 30-meter resolution from the thematic mapper on one of NASA's Landsat satellites. Until now, "a lack of power and the high prices of computer hardware" necessary to process the images have inhibited potential users, Walklet said [see "Why remote sensing is an information technology," p. 26].

Within just a few years, however, two critical technologies have become both available and affordable: powerful graphics workstations for displaying the data, and affordable commercial software for manipulating them. Consequently, satellite data are in wider use than before and being mixed and massaged with greater ingenuity, too—even though some of the satellites still operating were launched in the 1980s and employ relatively old sensor technology.

With the software, maps can be generated directly from satellite data, and special-use images can be created by fusing or combining data obtained from different satellites or from nonsatellite databases. More surprisingly, subpixel analysis is extracting information about an image's content in finer detail than the image's own spatial resolution.

The result? Remote-sensing data are being used not only for monitoring climate and agriculture and discovering natural resources (as they have for years), but also for keeping tabs on payments of real estate taxes, fighting the import of illegal drugs, and for other special purposes.

Not including military and weather satellites, some 14 land-sensing satellites from diverse nations are operating in orbit around the earth; all were launched before September 1993, and seven were launched in the 1980s [see

table]. Other sensors have been put into temporary orbit aboard the U.S. space shuttle, the Russian Mir space station, and similar short-lived platforms. Now high-resolution commercial remote-sensing satellites are being built.

Wavelengths at work

Regardless of their nation of origin, the long-lived satellites have general similarities. Most are in low earth orbit at altitudes of about 550 to 900 km. Most have passive multispectral sensors that look at the earth by simultaneously registering several bands of the electromagnetic spectrum—two or three bands in the visible part (usually in the red and the green and sometimes also the blue, between 0.4 and 0.7 μm), and one or more in the infrared region.

The bands in the visible and the near and mid-infrared (0.7 to 5 μm) detect the sun's radiation reflected off the earth. As this reflected light and heat is visible only during the day, most remote-sensing satellites have circular, sun-synchronous polar orbits with periods of roughly 100 minutes. In such an orbit, the satellite crosses a specific line of latitude at approximately the same local sun angle on every orbital pass; meanwhile, the earth will have turned underneath the satellite during that interval, presenting new territory to be examined.

Part of the earth's radiation, however, is emitted by earthly objects themselves because they are warmer than absolute zero. The longer wavelengths (5–1000 μm) of this thermal infrared activity can be detected in the dark, when the satellite is in the nocturnal half of each orbit. Some of the satellites observe in one or more thermal infrared bands.

Essentially, each spectral band produces only a monochrome picture of the scene. Combining the data from several bands, each in a separate (arbitrary) color, generates a multicolor image filled with all kinds of useful information, depending on which bands are utilized. Choosing an assortment of colors to reveal each object's unique spectral signature—that is, its pattern of absorbing, transmitting, or reflecting radiation from several spectral bands—can be used to classify the type and

TRUDY E. BELL
Senior Editor

◀ At an altitude of 213 km above Egypt, the Russian KVR-1000 (high-resolution camera with a focal length of 1000 mm) acquired this image of part of Cairo in February 1991. Spatial resolution is about 1 meters. The panchromatic film is sensitive to visible wavelengths of 570–730 nm [green to red]. Covering 40 km by 40 km, the full photograph shows far more detail than images from civilian satellites do. A magnified section [inset at top] shows the airport with individual aircraft; the inset at bottom exposes the Giza Pyramids on the edge of the Sahara desert. Digitized KVR data is now available through the Earth Observation Satellite Co. (Eosat) in Lanham, Md., and is useful for identifying geology, water resources, land cover, and making maps for urban planning.

health of vegetation or describe bodies of water. For example, combining the data from the visible red, green, and blue bands creates a natural-looking image that penetrates some shallow water and shows water currents, turbidity, and sediments—knowledge useful for bathymetric and coastal studies. Combining red, near-infrared, and mid-infrared data, in contrast, more clearly delineates inland lakes and streams and reveals moisture variations—useful for the analysis of soil and vegetation. In short, the process can classify surface features with high accuracy.

Visible and infrared imagery has its limitations, even so. The chief drawback is that it is blocked by clouds, haze, and rain. Enter active sensors: synthetic-aperture radar (SAR). One such system is on board the European Space Agency's ERS-1 satellite; others have been carried on the space shuttle. A SAR system beams microwave radiation toward the earth and detects the returned echoes. Radar is excellent for penetrating haze, light rain, clouds, and even some tree cover and other vegetative canopies. Although large amounts of moisture or standing water stop the return, in exceedingly dry areas such as deserts radar has actually pene-

trated the ground to a depth of 3 meters. It is also good at revealing topography, despite its single-band nature, which makes it difficult to classify surface features and vegetation. Last, as an active remote-sensing system, radar works as effectively at night as during the day.

Data fusion

Combining data from one sensor taken at different times or from several sensors—even from different satellites—reinforces the strengths of each type and elicits different sorts of information about the earth.

Fifteen months ago, the radar of ERS-1 pierced the cloud cover over Germany and France to record the worst flooding in Western Europe in 60 years. A merger of radar data collected on two different days highlighted changes due to flooding of the Rhône River in southern France [see figure, p. 27]. Authorities relied on the merged data gathered during and after the floods to help them set priorities for rescue, clean-up, and reconstruction.

The digital merger of radar data with the data from two or more visible and infrared bands yields the best of both worlds: sharp relief with surface classification. Similarly, it is possible to merge the

multispectral data from Landsat's thematic mapper data with black-and-white photographs taken by the KVR-1000 camera on board a Russian satellite [see figure, p. 28, top]. The thematic mapper's 30-meter resolution is enhanced by the 2-meter resolution of the digitized photographs.

The KVR-1000—so named for its 1000-mm focal length and the Russian words for high-resolution camera (Kamera Vysokogo Razresheniya)—was used as a reconnaissance camera by the former Soviet Union. Several times a year, the Russians launch a KVR-1000 into orbit, to circle the planet for about 45 days. It photographs about half the land surface along its ground track from a relatively low circular orbit of 220 km with a nominal inclination to the earth's equator of 65 degrees.

From that altitude, the KVR-1000 photographs have a spatial resolution of 2–3 meters, as if shot from a high-flying reconnaissance aircraft. The detail is such that in one image of the airport at Cairo, Egypt, "you can see individual aircraft," said Vicki Williams, a senior applications specialist for Earth Observation Satellite Co. (Eosat), Lanham, Md. To make the Russian images of much of the world's surface available commercially, Eosat is one of the

Why remote sensing is an information technology

So great are the demands of processing any image from on high that commercial satellite remote sensing is still far from becoming a real-time technology. Today's conversion of raw commercial satellite data into finished images takes an average of one to two weeks.

Why so long? "Remote sensing data is like raw wheat," said Donn C. Walklet, president and chief executive officer of TerraNova International in Los Altos, Calif. In his view, both commodities must undergo extensive processing to be useful, whether as imagery or as bread. Yet in the remote sensing world, "we expect the customer to pull up his or her truck to the farmer's 'grain elevator,' haul away the raw product to 'mill,' and subsequently process the raw material into some form suitable for consumption."

To sustain the metaphor, the data must not only be harvested, but also be winnowed, ground, and baked.

Most earth-resources satellites return digital data from passive sensors. Passive sensors exploit the fact that every object on earth reflects solar electromagnetic radiation or else emits its own radiation. (ERS-1, launched by the European Space Agency in 1991, returns digital data from

active radar sensors that detect microwave radiation beamed to earth from the satellite itself. As for the short-lived Russian remote-sensing satellites, they return photographic film, not digital data, to earth.)

Some satellites (such as Landsat) have scanning-mirror instruments, and others (such as SPOT and IRS) have push-broom sensors. As the satellite travels north and south in its near-polar orbit, the scanning mirrors swing east and west to define a scan line, building up the basics of a two-dimensional image. The push-broom instruments, in contrast, image a complete line at a time.

Remote-sensing satellites in low earth orbit circle the planet about every 100 minutes, so the rotation of the earth below presents new terrain with each orbit. After 14 to 44 days (depending on the satellite), the starting point returns and the cycle is repeated.

Thus, in each cycle, the satellite traces out several hundred swaths (paths) running from pole to pole; each swath is divided into several hundred rows. In remote-sensing parlance, a scene is one swath/row combination; an image is one scene made on a particular date.

For both scanning and push-broom

sensors, the along-track dimension of a sensor's pixels, or its instantaneous field of view, is determined by three factors: the sensor's orbital altitude, velocity, and detector integration time. The cross-track dimension is determined by the scan rate in scanners and by the detector's size in push-broom sensors. The pixels' angular size and the satellite's altitude together define the sensor's spatial resolution on the earth.

Each sensor on a remote-sensing satellite assigns several digital values to each pixel, corresponding to the measured radiation levels in its various bands. The pixel values are transmitted to earth for archiving on high-density computer tapes.

A Landsat illustration suggests just how much raw data this represents for one of the coarser-resolution remote-sensing satellites in orbit.

On each Landsat, the thematic mapper assigns seven values to every pixel—one value per measured radiation level of seven spectral bands (three visible and four infrared). As there are some 40 million pixels in every Landsat thematic-mapper scene, some 200–300 MB of data are used to represent it (each scene measures 170 km along the north-south axis by 185 km east-west).

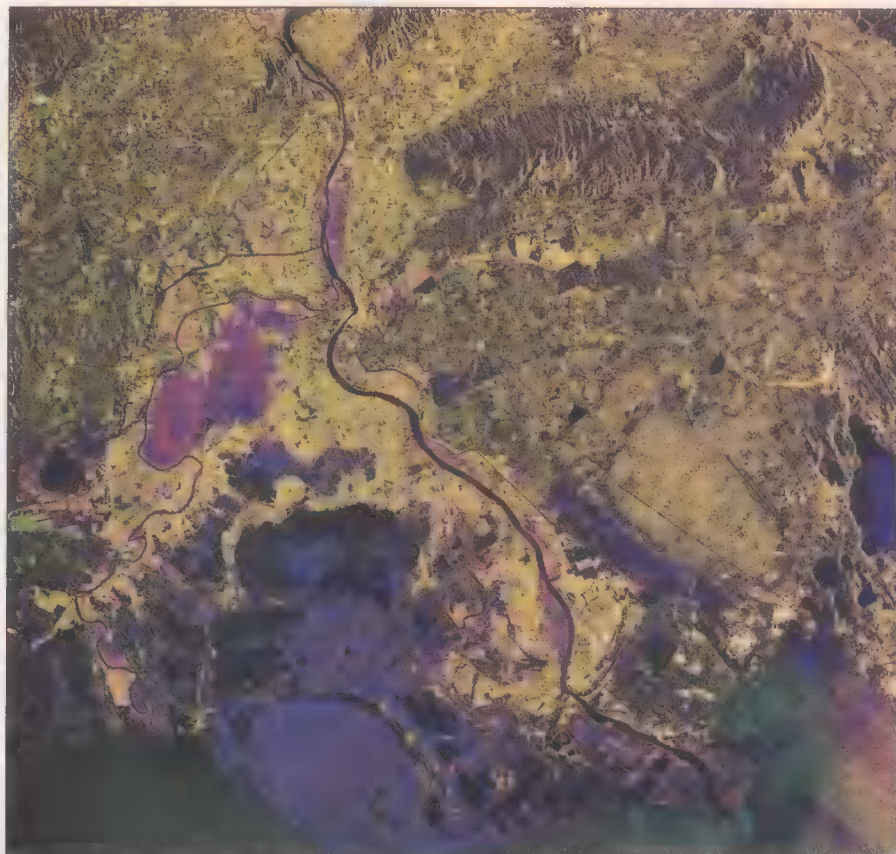
Every two weeks, each Landsat satel-

companies that has established a facility in Moscow to digitize some 2 million original negatives collected since 1982 [see photographs on p. 24].

Hands-on mapping

One use for remote-sensing imagery is improving the type of information shown on maps. One example of software available for turning remote-sensing images into maps of cartographic quality is the Erdas Imagine system. Developed by Erdas Inc., Atlanta, Ga., Erdas Imagine can display, analyze, and combine raster and vector data from satellite images, aerial photographs, and other sources. It can also

► Two radar images of the southwestern part of Provence, the Rhône River and its delta, and the Mediterranean coast were taken a week apart and subsequently merged to highlight changes wrought by last year's flooding in Western Europe. One image from the European Space Agency's ERS-1 satellite was obtained Jan. 3 [in red], the other on Jan. 12, 1994 [in green]. A ratio of the red-to-green images is displayed in blue. Significant changes shown in magenta, indicating heavy flooding.



EUROPEAN SPACE AGENCY

lite transmits to earth 10 000 scenes or so (not every possible scene is acquired, particularly over the oceans), or nearly 3 terabytes of data. Multiply that total by two satellites and 26 cycles in a year, and the upshot is a veritable firehose of raw data.

(And this is just for the United States. Meanwhile, France, Japan, Germany, and India are being deluged with even more terabytes from their own satellites.)

If, as expected, satellite systems having 1-3 meters of spatial resolution are launched within the next few years, the firehose may grow to 1 terabyte per day.

Turning all that raw data into finished images also requires hefty computing power, not least to get rid of three categories of error.

First, the raw data contains geometric distortions that must be corrected before they can be used. The earth rotates eastward under a satellite traveling north-south while it picks up scenes of what's below. As each scene takes half a minute to acquire, the spinning earth skews the raw image from a rectangle into a rhomboid.

If a spacecraft has scanning mirrors, this skewing is compounded by vibrations within the moving parts, which cause pointing errors in the sensors' viewing angle. Further distortion comes from the nonconstant motion of scan

mirrors during each scan. Because of this motion, the distances between successive pixels may vary.

Then, too, the detectors for each spectral band have different physical locations on the satellite's focal plane, giving rise to a misregistration between the bands in the raw images. And, of course, there is a geometric distortion introduced by the sensors' imaging of the earth—a three-dimensional surface—in two dimensions.

To compensate for these distortions, instruments on the satellite monitor all the possible geometric angle and vibrational errors and transmit payload correction data along with the pixel values. That data corrects the distortions in the raw image data so the pixels are properly placed on the processed image relative to their actual location on earth.

A second reason why so much computer power is needed is radiometric imbalances in the raw data. Within each spectral band measuring radiance from the earth, a satellite has not just one detector but several. On each Landsat thematic mapper, for example, each of the three visible bands and the three near- and mid-infrared bands have 16 detectors while the thermal infrared band has four detectors—a total of 100. Since no two detectors and their accompanying electronics are ever identical,

each records a slightly different value.

On board the satellite, each sensor is calibrated by having its detectors record the brightness of calibration lamps after every scan. The calibration data is further analyzed back on earth to determine what gains and biases must be applied to the raw data to account for each detector's independent behavior. The goal is to ensure that all detectors use the same data number for the same input radiance.

A third call on computer power stems from atmospheric effects: unwanted energy or "noise" scattered into the sensors' field of view. The atmosphere transmits and absorbs electromagnetic energy, in the process altering it spectrally. Atmospheric scattering occurs when the direction of the energy is changed unpredictably by encounters with particles, water vapor, dust, and molecules in the atmosphere. Haze results, and images lose clarity. If desired, atmospheric effects can be corrected by the use of algorithms.

Because of the huge daily flood of data and the massive computing power required to process each image, most remote-sensing satellite data are archived in their raw form. They are seldom corrected except in response to a customer's order.

—T.E.B.

classify land cover, extract image features, register different types of data in one file, as well as rectify, warp, and rotate images to conform to more than 100 projections. Add-on modules allow a user to interpret and combine radar data with other imagery and to customize Erdas Imagine for specific applications. Erdas Imagine is available for DOS systems, Windows NT, and most Unix-based workstations; it is slated to be available on Windows 95 within 60 days of the software's release by Microsoft Corp.

Other PC-based systems for turning remotely sensed images into maps have also been developed. The Environment for Visualizing Images (ENVI) can be run by anyone having access to an IBM 486 DX with the Microsoft Windows NT operating system or an Apple Macintosh with System 7 or higher. The package was unveiled last year by Research Systems Inc., Boulder, Colo. Another package, EASI/PACE software for processing raster-scanned imagery, is a product of PCI Remote Sensing Corp., Richmond Hill, Ont., Canada. It can be run under Microsoft Windows 3.1 on any desktop system displaying up to 24-bit true-color imagery. Depending on configuration, image-processing software for PC systems can cost anywhere from US \$2000 to \$5000; that for Unix workstations ranges from \$3000 to \$10 000.

Such available and affordable power is firing people's imagination as to the uses to which remote-sensing data might be put. One such inspiration occurred to the Maryland State Government Geographic Information Coordinating Committee, founded in 1992. The group is using the land-classification information in Landsat



► Part of southeast Munich is imaged in this digital merge of Landsat thematic mapper scene with digitized black-and-white photographs by a Russian KVR-1000 camera aboard a Kosmos spacecraft. By combining the higher resolution (2 meters) of the panchromatic photography with multispectral information having 30-meter resolution, the merge facilitates the identification of surface features of use for detailed mapping. The KVR image was acquired on May 16, 1992, and the mapper image on June 29, 1992.

SOVINFORMSPUTNIK/EOSAT

imagery to update Mylar maps of Maryland's 1.8 million properties, originally based on U.S. Geological Survey maps made in 1950. The Mylar property maps are also being converted into electronic form. When the job is complete, a user will be able (among other possibilities) to click on any parcel to review its zoning and land use status and its accounts including whether its property taxes have been paid, said John M. Morgan III, Geographic Information Systems Laboratory director and an associate professor in the department of geography and environmental planning at Towson State University in Maryland.

Beyond the resolution limit

The spatial resolution of just about any satellite image is larger than many of the objects of interest within the image. The

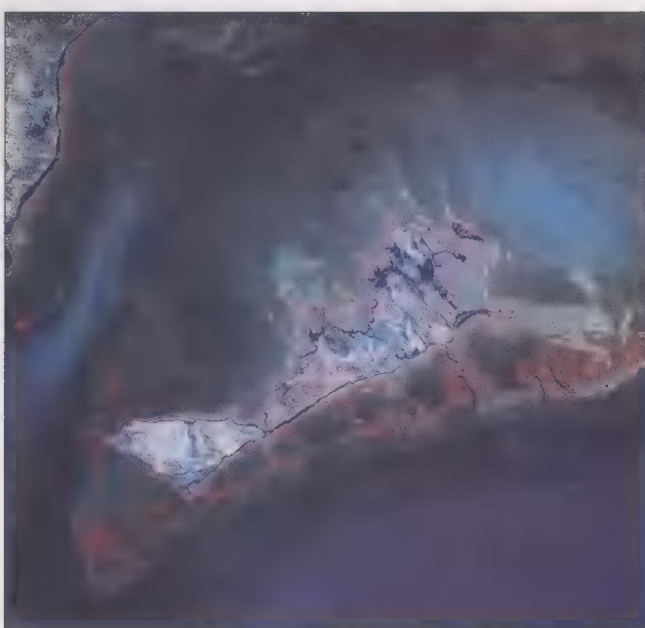
pixels in a multispectral image from the French SPOT satellites, for example, are 20 meters on a side, while the pixels in a multispectral Landsat thematic mapper image are 30 meters on a side.

One way to identify objects is by their shape. But any feature (a tree, a road, a vehicle, a building, or an outcrop of rock, say) smaller than the spatial resolution will not be distinguishable as a separate entity. Another method is using the object's spectral signature—that is, the intensity of the object's spectral reflection over a range of wavelengths—as the key to identification. The spectral signature of a small feature will contribute to the overall brightness and spectral distribution of the pixel in which it appears.

Software tools are now available to facilitate the separation, or unmixing, of the spectral components that make up the overall reflectance pattern of each pixel. For example, a program from Applied Analysis Inc., Billerica, Mass., allows users to detect and classify objects that are actually smaller than the size of an image pixel.

Its inventor, Robert L. Huguenin, Applied Analysis's chief technical officer, and his president, Donald B. Damm, said the technique treats spectra of the units of interest as reference signatures. These signatures are automatically subtracted from the spectra of whole pixels so as to characterize the spectrum of the background. Next the background spectrum is subtracted from candidate pixels. Each candidate's residual spectrum is then compared with the reference signatures. If the residual spectrum agrees with the reference signature within an

► The underwater contours of coastal Tunisia were revealed by processing the green, red, and near-infrared spectral bands of a Landsat thematic mapper image. First, variations in water turbidity, seafloor composition, and atmospheric conditions were removed by applying a GeoView multispectral processing algorithm, which is proprietary to Earth Satellite Corp. (EarthSat), Rockville, Md. From the result, an analyst using a bathymetric chart for reference derived a depth image for the water. That image was then color-coded to mark discrete intervals in the water's depth and recombined with the land areas into the final image. Bathymetric and coastal information is crucial for such applications ■ exploring and developing near-shore petroleum, selecting pipeline routes, and identifying environmentally sensitive areas.



EARTH SATELLITE CORP.

Land-resources satellites and sensors operating in low earth orbit

Sponsor	United States	France	United States	Japan	India	Japan	Europe
Satellite	United States	France	United States	Japan	India	Japan	Europe
Name	Landsat 4, 5	SPOT -1, -2, -3	NOAA -10, -11, -12	MOS -1a, -1b	IRS -1A, -1B	JERS-1 (=FUYO-1)	ERS -1
Launch date(s)	1982 & '84	1986, '90, & '93	1986, '88, & '91	1987 & '90	1988 & '91	1992	1991
Orbit							
Altitude, km	705	632	845-861	909	904 ■ 900	568	785
Inclination	98.2°	98.9°	98.9°	99°	99.5°	97.7°	98.5°
Period, min	98.9	101.4	102	103	103.2	96	100
Repeat coverage, days	16	26	—	17	22	44	35
1st sensor system							
	Thematic mapper	Multispectral HRV ¹	AVHRR ²	VTIR ³	LISS ⁴ -I	Optical Sensor	AMI ⁵
Swath width, km	185	60-80	3000	1500	148	75	[operates at 5.3 GHz in three synthetic-aperture radar modes]
Resolution, meters	30	20	1100-4000	900, 2700 ^c	73	18x24	
No. of bands:							
Visible ^a	3	2	1	1	3	2	
Near/mid-/thermal IR ^b	1/2/1	1/—/—	1/1/2	—/—/3	1/—/—	2 ^d /—/—	
2nd sensor system							
	Multispectral scanner	Panchromatic HRV ¹		MESSR ⁶	LISS ⁴ -II	SWIR ⁷	ATSR IRR ⁸
Swath width, km	185	60-80	—	100	74 per camera	75	500
Resolution, meter ■	80	10	—	50	36.5	18x24	1 nadir, 1.5x2 forward
No. of bands:							
Visible ^a	2	1		2	3	—	—
Near/mid-/thermal IR ^b	2/—/—	—/—/—		2/—/—	1/—/—	—/4/—	—/2/2
3rd sensor system							
				MSR ⁹	LISS ⁴ -II	SAR ¹⁰	ATSR ⁷ MS ⁸
Swath width, km	—	—	—	317, 317	(as above)	75	—
Resolution, meters	—	—	—	3200, 2300	—	18	—
Bands	—	—	—	23.8, 31.4 GHz	—	1.275 GHz	23.8, 36.5 GHz
4th sensor system							
							Radar altimeter
Band	—	—	—	—	—	—	13.8 GHz

■ 0.4-0.7 μm.

b 0.7-1.5 /1.5-5.0 /5.0-12.5 μm.

c 900 meters for visible band, 2700 meters for infrared.

d One looks forward, the other straight down, to make a stereo pair.

1 High-Resolution Visible.

2 Advanced Very High Resolution Radiometer.

3 Visible and Thermal Infrared Radiometer.

4 Linear Imaging Self-Scanning Camera.

5 Active Microwave Instrument.

6 Multispectral Electronic Self-Scanning Radiometer.

7 Shortwave Infrared Radiometer.

■ Along-Track Scanning Radiometer—Infrared Radiometer/Microwave Sounder.

9 Microwave Scanning Radiometer.

10 Synthetic Aperture Radar.

Source: Earth Observation Satellite Co. (Eosat)

allowed set of tolerances, the candidate pixel is identified as containing the unit of interest.

That ability to classify subpixel-sized materials is expected to permit the mapping of individual species of vegetation. Tests have already found it about 90 percent accurate in detecting bald cypress and tupelo in test sites in the wetlands of Georgia and South Carolina [see image, p. 30, top]. According to Huguenin and Damm, the technique is sensitive enough to detect whether a pixel contains as little as 20 percent of the material of interest. The process does *not* reveal where in the pixel the unit of interest occurred; it indicates only whether the pixel contains the unit, and how much of the unit is present in the pixel. The subpixel analysis technique will be commercially available in the second quarter of this year, when it debuts as a module for the Erdas Imagine image-processing software.

The Linear Spectral Unmixing function in ENVI is another subpixel analytical rou-

tine. For use in quantitative compositional analyses, ENVI includes spectral reference libraries of hundreds of minerals and plants, compiled by the U.S. Geological Surveys and NASA's Jet Propulsion Laboratory [see figure, p. 30, bottom].

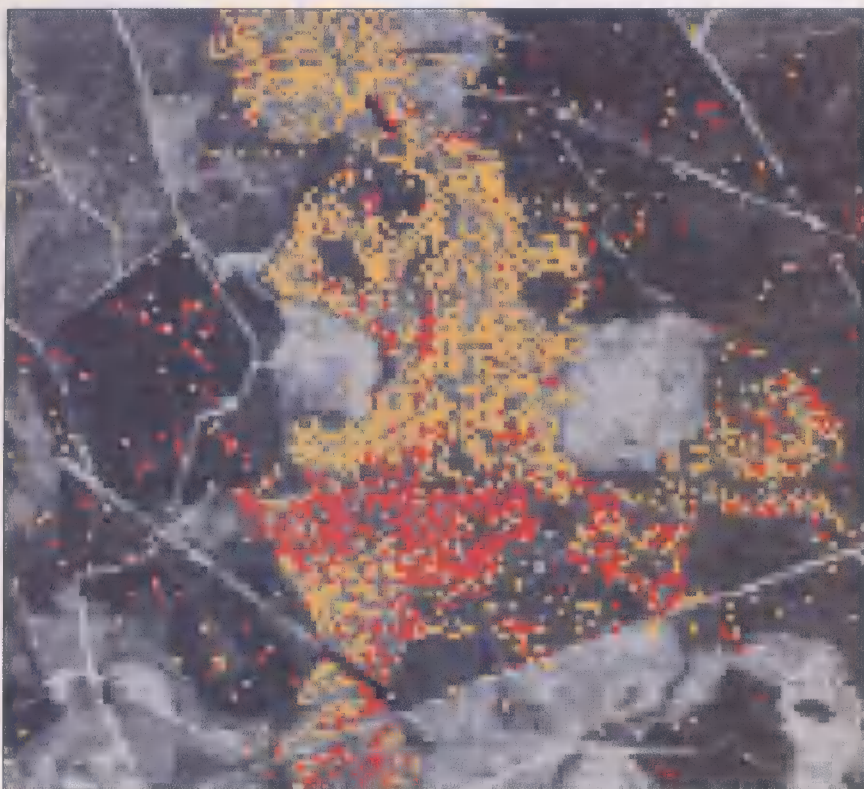
From any viewing angle

The capacity to create two-dimensional maps from satellite imagery has been around for many years. Ascertaining the third dimension—elevation—requires a lot more computing power. In its simplest form, such topographic information can be determined by photographing terrain from two angles and combining the images stereoscopically. Now commercial photogrammetric software—such as Erdas Imagine's Orthomax—allows users to derive elevation contours for terrain from stereo-pair satellite imagery in nearly automatic fashion.

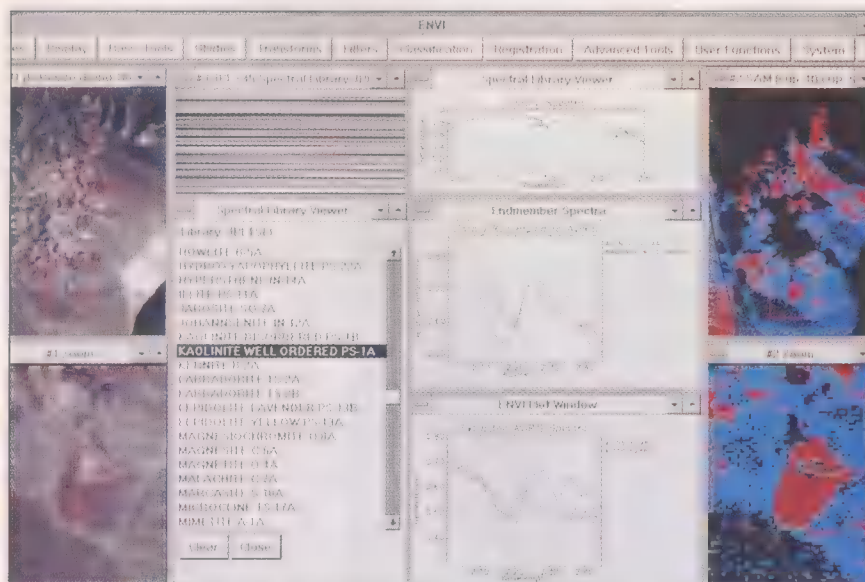
Stereo pairs may be created in three ways. One is by taking two images from one satellite on separate passes (as with

the SPOT panchromatic system). A second way is to combine images from two satellites made on different passes at two viewing angles. A third way is to make two overlapping images simultaneously (as does Japan's JERS-1, which has two cameras in the same near-infrared band, one looking forward and one looking straight down).

Software also enables a user to view any terrain from any angle. That feature is offered by the Wings Mission Rehearsal interactive graphic simulation software from Autometric Inc., Alexandria, Va. Two-dimensional imagery from a Landsat, SPOT, or other remote-sensing satellite can be mathematically "draped" over a wire-frame topographic grid created from the U.S. Defense Mapping Agency's Digital Terrain Elevation Data. The result is realistic landscapes that then can be displayed from any angle, as if viewed from an aircraft flying over the land. Users also have the option of displaying the positions of fixed objects and the locations of



▲ This image of an inland wetland near Charleston, S.C., was subjected to subpixel analysis, which reveals the presence of some objects smaller than the resolution of the image's sensor—a Landsat thematic mapper. Bald cypresses have a detectable effect on a pixel's spectral signature. A standard analytical technique counted only those pixels containing just bald cypress [red], but cypress trees were found scattered over a far larger area [yellow] by a subpixel technique proprietary to Applied Analysis Inc., Billerica, Mass. Since bald cypresses require standing water for at least part of the year, their presence means that the wetland itself was larger than depicted by the supervised minimum-distance classifier of tradition. In some of the yellow pixels, only 20 percent of the vegetation is cypress trees.



▲ The presence of minerals can be revealed by subpixel analysis. A technique proprietary to Research Systems Inc., Boulder, Colo., was applied to an image of Cuprite, Nev., which had been collected by an airborne instrument called AVIRIS (Airborne Visible Infra-Red Imaging Spectrometer) from 224 visible and infrared bands. The commercial software package ENVI (Environment for Visualizing Images) for Windows revealed the presence of allunite [red] and kaolinite [blue] by comparing their spectra to reference spectra from NASA's Jet Propulsion Laboratory's Spectral Library [right].

moving and airborne objects in real time.

One of the first military uses of Autometric's computational and display technology was in 1991, when the U.S. Marines used Wings software on a Silicon Graphics 340 VGX computer to rehearse their Desert Storm missions in the Persian Gulf. More recently, the Wings software has been used to plan relief operations for Bosnia [see image opposite].

Future sensors

Launches of the next generation of remote-sensing satellites will begin this year and are scheduled to continue into 1997. Of the first three, one is India's IRS-1C, with two bands in the visible and two in the infrared to supplement existing coverage by the Landsat and IRS satellites.

Another is Germany's MOMS-02 (Modular Optoelectronic Multispectral Scanner), scheduled for launch aboard the Priroda platform on the Mir space station. MOMS-02 will return imagery (including stereo pairs) of vegetation and geological features.

The third is Canada's first remote-sensing satellite, Radarsat, which will carry synthetic-aperture radar for monitoring sea ice and other marine environments. Its resolution of 50 meters will help to support fishing, shipping, oil exploration, offshore drilling, and ocean research. The spacecraft is to be launched in August from Vandenberg Air Force Base in southern California.

Future remote-sensing satellites are being planned, some for the international Earth Observation System (EOS) to monitor the global environment. Instead of carrying multispectral instruments covering up to seven spectral bands, these will have hyperspectral instruments gathering imagery in 30 or more spectral bands.

Also planned for launch in the next year or two are compact "smallsat" commercial systems having a resolution equivalent to those of reconnaissance systems: 1–3 meters panchromatic. Several "smallsats" are being built by CTA, Eyeglass International (a joint venture of Orbital Sciences, Itek, and GDE Systems), Space Imaging (a joint venture of Lockheed and E-Systems), TRW, and WorldView Imaging in cooperation with Ball Aerospace. Meanwhile, the commercialization of former military reconnaissance data is being continued.

To probe further

For details about satellites used to monitor changes in the climate and the environment, including the planned global Earth Observation System (EOS), see "Sensing climate change," by Glenn Zorpette, *IEEE Spectrum*, July 1993, pp. 20–27.

For a description of plans to handle the EOS's

anticipated torrent of data, see "Dealing with the data deluge," by Nahum D. Gershon and C. Grant Miller, *Spectrum*, July 1993, pp. 28-32. For a more detailed discussion of the problem, turn to *Remotely Sensed Data: Technology, Management, and Markets*, Washington, D.C. It was issued by the U.S. Congress' Office of Technology Assessment, in September 1994, as Report No. OTA-ISS-604.

A succinct overview of the currently operational remote-sensing satellites of all nations is Appendix D in *The Future of Remote Sensing From Space: Civilian Satellite Systems and Applications* by the U.S. Congress' Office of Technology Assessment, Report No. OTA-ISC-558, published in July 1993 by the U.S. Government Printing Office. To learn more on international cooperation, including the commercialization of Russian imagery, see the OTA's Report No. OTA-ISS-607 (September 1994) *Civilian Satellite Remote Sensing: A Strategic Approach*.

Offering a concise introduction to Applied Analysis Inc.'s technique is "Subpixel Analysis: Process Improves Accuracy of Multispectral Classifications." Written by Robert L. Huguenin, the article appeared in the July 1994 issue of *Earth Observation Magazine*, Vol. 3, no. 7, pp. 37-40.



▲ A three-dimensional image [bottom] of Bosnia was created with the Wings Mission Rehearsal software by Autometric Inc., of Alexandria, Va. The software took two-dimensional thematic mapper data from a U.S. Landsat satellite (with 30-meter resolution) [top] and mathematically "draped" it over digital terrain elevation data (with 100-meter accuracy) obtained from the U.S. Defense Mapping Agency. The purpose was to allow military pilots to simulate flying over terrain before an actual mission.

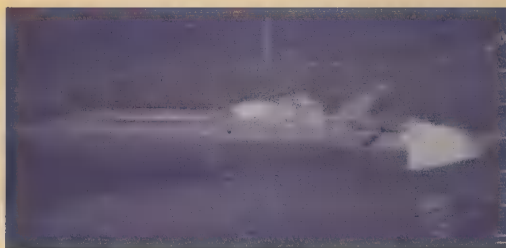
Remote sensing versus crime

Airborne and satellite remote sensing have also played a role in combatting crime. "People dealing drugs, burglarizing homes and cars, or engaging in other criminal activity believe they are protected by cover of darkness," said Dean Queathem, vice president of marketing for the night vision systems and sensors division of FLIR Systems Inc. in Portland, Ore. "Typically, large ships will transfer their cargo of illegal drugs to small, fast speed-boats that then run into coastal towns. Law enforcement officials get reports of such criminal activity, but the information is not useful if the officers can't see what's going on."

The answer? Penetrate the darkness of night by picking up an object's natural thermal infrared emissions. Any object above absolute zero emits thermal infrared radiation (heat)—hotter objects (such as fires or engine exhaust at about 500 K) at shorter wavelengths (3-5 μm) and cooler objects (such as human bodies at about 300 K) at longer wavelengths (8-14 μm).

A night vision system generally consists of a turret (an infrared sensor

enclosed in an electromechanical housing or gimbal), an electronic module, a control unit, and a video display. Usually, the turret is mounted on an aircraft or



ship while module, unit, and display are inside the aircraft cockpit or cabin. The electronic module is the central processing unit both for input from the control unit to the turret and for output from the turret to the video display. The infrared sensor incorporates the most critical components of the system, including a detector assembly, closed-cycle cooler, scanner optics, and electronics.

FLIR Systems uses two types of infrared focal plane arrays: serial scanning and staring. In the serial scanner, a high-speed scanning mirror reflects the infrared radiation to a four-by-four array of detectors. The staring focal plane array, on the oth-

er hand, simply stares at the scene, for by integrating the radiation over a longer time than can the detectors in the scanning array, it can sense very low-intensity, ambient infrared radiation.

The serial scanner employs detectors made of mercury-cadmium-telluride; the staring focal plane array sensors are made of platinum silicide. In each case, the detectors are mounted on a dewar and cooled to 77 K.

The U.S. Customs Service has used infrared technology to apprehend so-called cigarette boats importing illegal narcotics [see photograph]. Moreover, infrared remote sensors have ferreted out sites where illegal drugs were being manufactured. "A lot of heat is involved in growing illegal drugs, particularly marijuana," which is commonly raised under grow lights, Queathem noted. Scanning houses or other structures on a cool night might reveal that a certain building is very hot or that a transformer on an adjoining power pole is hot from so much power being drawn for grow lights, he said.

Yet other law-enforcement agencies have employed remote-sensing imagery from satellites to identify the spectral signatures characteristic of coca-growing operations in South America. Coca is the plant from which cocaine is derived.

—T.E.B.

SLOWING THE AGING OF NUCLEAR POWER PLANTS

NUCLEAR POWER PLANTS, like people, need more maintenance as they age. For us, this means additional medical checkups, nothing a doctor need fear; but for a nuclear plant, more frequent maintenance exposes the pool of workers involved to greater radiation overall.

Two other factors make a bad situation worse. Nuclear plants get "hotter" as they age, so that just when they need more care, they raise the radiation ante for those qualified to maintain them. And the latest U.S. Federal regulations have become tighter, limiting still further the permitted annual exposure of any individual to the damaging rays. The operator of an aging nuclear plant is therefore caught between conflicting obligations: to increase the maintenance of an ever hotter facility, yet keep the exposure of each worker to an unprecedentedly low level.

All done by chemistry

The solution chosen by the U. S. utility industry is chemical decontamination—more specifically, decontamination of the system that cools the nuclear reactor, namely, the full primary, or reactor coolant, system. The process is actually under way right now, about 65 km north of New York City, at the Indian Point 2 pressurized-water reactor plant of the Consolidated Edison Co. of New York Inc. It is the nation's first such application of chemical decontamination to an operating commercial nuclear power plant.

The event is being treated as a national demonstration to ensure that it benefits the entire U.S. utility industry. More broadly still, the consortium taking part is an international group of utilities and other organizations, to ensure improved technolo-

Maintenance of
a reactor coolant system is
made safer when its surfaces
are periodically cleansed of
radioactive oxides

gy transfer to other utilities all over the world.

The decontamination of the full primary system is being demonstrated with the fuel elements removed, during a scheduled outage for refueling. The process began last month and is due to be completed in early March. The expectation is that it will slash 80 percent from radiation field levels within the plant.

Naturally, the effort now going on has precursors. For more than two decades, research into the chemical decontamination of individual components and subsystems has been conducted by a good many organizations. Con Edison and New York's Empire State Electric Energy Research Corp. (Eseerco) did a lot, and so did the Electric Power Research Institute (EPRI). Their work established that a chemical approach can rid a variety of components and systems of much of their radioactivity without detriment to their long-term reliability.

Nevertheless, from decontaminating individual components to decontaminating a full primary system is a significant technological step. The systems affected, the technical issues to be addressed, and the logistics for undertaking chemical decontamination on such a large scale certainly confront

STEPHEN A.
TROVATO
and
JOHN O. PARRY
*Consolidated Edison Co.
of New York Inc.*

JAMES M. BURGER
*Empire State Electric
Energy Research Corp.*

the nuclear power industry with a major challenge.

In any power plant using a pressurized-water reactor, products of corrosion and wear are to be found throughout the reactor-coolant system [see drawing to right, below]. These products circulate with the primary coolant through the reactor, where some of them may become radioactive. A variety of radioisotopes are created in this manner, and for the most part, they are removed by being filtered and demineralized in the chemical and volume control system. Whatever is left over forms a metal-oxide layer on the coolant system surfaces. These extensive and inaccessible areas include the surfaces of the fuel elements, the chemical and volume control system, and the other primary support systems.

The metal-oxide layer is deposited under slightly reducing conditions, so that it shapes up as a black spinel consisting mainly of oxides of iron, chromium, and nickel but including other elements, too. Cobalt, manganese, and zinc are among those elements present in small but significant quantities. Many radioisotopes of these lesser groups are trapped in the oxide layer, sometimes as replacements for the iron, nickel, and chromium. But removal of the trapped radioisotopes is not easy, so tenaciously does the oxide layer cling to plant surfaces.

The amount of radioactive material left on the assorted surfaces is variable. It depends principally on the corrosion rates of the plant materials, the chemistry of the primary water used as coolant, and the number of sources of cobalt. In a pressurized-water reactor, the largest contribution to the radiation fields is made by two radioisotopes of cobalt—Co-58 and -60. Very little cobalt is needed to generate a lot of radiation. A single gram of Co-60 produces approximately 1100 curies of radiation activity, and 1 curie of the isotope yields a radiation field with an intensity per hour of 11 rems at a distance of 1 meter.

Now the radioactive half-life of Co-60 is 5.2 years. Consequently, even minute amounts of cobalt released into the system through corrosion can influence the running of a plant over a long period of time.

At first, after the original plant start-up, the radiation fields of the oxide layer build, but after several years they typically level off. Gamma rays are the chief component. Workers are exposed to the radiation while maintaining the plant, above all during outages for refueling, when they perform routine maintenance on major plant components, such as reactor coolant pumps and steam generators. Because a steam generator requires such extensive maintenance, it usually gives workers their largest dose of radiation—and its radiation field can be as high as 40 rems per hour.

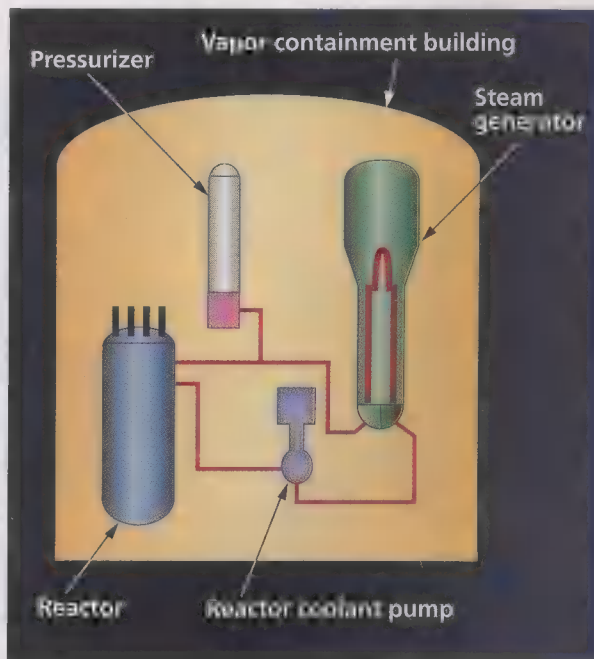
Why full-system clean-up

In violent contrast, the upper limit set by the latest Federal regulations is 5 rems per year per individual. In fact, the International Committee on Radiation Protection as well as the National Council on Radiation Protection, the latter located in Washington, D.C., have recommended that no person be exposed to a total of more than 5 rems

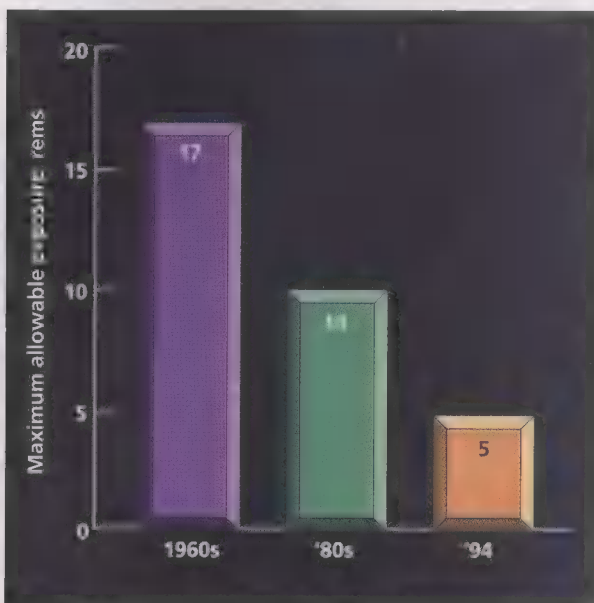
per year, from both internal sources (breathed or swallowed particles) and external. These limits are, on average, less than half the pre-1994 limits [see bar chart below].

The recommendation will affect utilities in several ways. Higher radiation doses from equipment and less exposure per worker add up to an unavailability of skilled labor once the technicians have run through their allowances. A labor shortage would be most likely to arise late in the calendar year, when annual allotments have been used up. The ruling would also leave a utility with less in the way of human resources with which to respond to emergencies.

Along with these lower exposure limits, Federal regulations were revised in 1994 to enact into law the "as low as reasonably achievable" (Alara) con-



◀ All materials corrode and wear with time in water, even very pure reactor water. As the corrosion products circulate through the nuclear reactor, they are bombarded by neutrons, so that some become radioactive. Some of those radioactive products deposit themselves in the metal-oxide layer that forms on the interior surfaces of the full primary, or reactor coolant, system shown here.



◀ Over the years, Federal government regulations have lowered the maximum amount of radiation to which an individual may be exposed in the course of a year. These bar figures include radiation that comes from breathed or swallowed particles as well as external sources.

cept, requiring that the exposure of personnel to radiation be minimized. The revision enables the Nuclear Regulatory Commission to set strict rules to ensure that the Alara concept is indeed realized.

Additionally, high levels of radiation reduce productivity. In a radioactive environment, more and larger crews are needed, and work is less effective. "Stay times" for crews are shorter, and set-up and clean-up times for men and material are much longer than they would be for the same work in a nonradioactive environment.

In other words, the component and subsystem decontaminations already performed have been of some benefit, but still greater benefits may be expected from decontaminating the full primary system. The far larger reduction in radioactivity will create a safer environment for the

workers, enhance productivity, and as a result keep the cost of operating nuclear power plants competitive.

The first findings

The complex geometry and inaccessibility of the reactor coolant system preclude the use of mechanical methods of removing the radioactive oxide layer. Research has instead focused on chemical means of dissolving the layer. Once dissolved, the radioisotopes are returned to the coolant solution, from which they can be removed by filters and demineralizers.

In the mid-1970s, with the support of the U.S. Department of Energy, Con Edison began research on the cobalt-containing oxide layer on the primary system, with a view to reducing plant radiation levels by dissolving the oxide. Earlier work

on chemical decontamination had targeted nuclear power plants scheduled for decommissioning, so that it did not matter what the condition of the equipment was after treatment. In the present situation, however, it is vital that a reactor's life not be shortened by the procedures used to decontaminate it.

The work on a nondestructive approach culminated in a focus on weak chemical solvents, like citric acid, which are further weakened by being used in low concentrations—less than 0.5 percent. In cleaning up plants being put out of commission, chemicals like hydrochloric acid have been used in concentrations of 1–10 percent. But because strong chemicals remove some base metal, they will not do for components that are to be returned to service. It is also hard to dispose of the kind of waste they produce.

Accordingly, in the late '70s and early '80s, Con Edison, EPRI, Eserco, and other organizations investigated at some length the compatibility of dilute chemical solvents with the materials employed in nuclear power plants. Luck was with them. Laboratory research could prove no ill effects, nor could more than 50 decontaminations of components and subsystems carried out by the utility industry in the field.

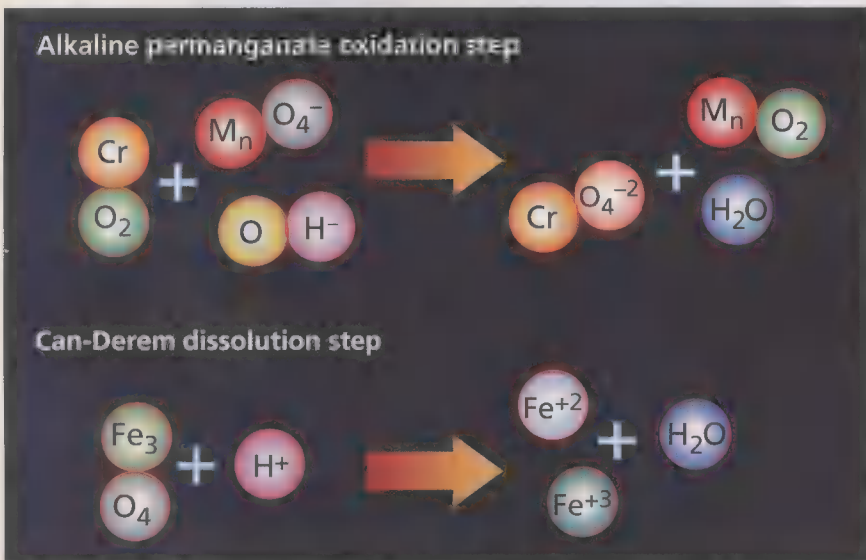
Two-stage attack

The early work of Eserco and Con Edison centered on a modification of a Canadian process. A single-step reduction had been developed by Atomic Energy of Canada Ltd. (AECL) for the country's heavy-water Candu reactors. But the oxide layers in pressurized-water reactors proved to cling too firmly to surfaces to be removable in one step.

So the researchers went to a two-step process [see diagram at left]. The revised version is called the AP/Can-Derem process, where AP refers to an alkaline permanganate pretreatment and Can-Derem (pronounced candyrem) is an AECL trademark.

The oxide's high surface tenacity is due to its high chromium content. In the first step, the alkaline permanganate oxidizes the chromium from CrO_2 to the soluble CrO_4 (actually Cr^{+3} to Cr^{+6}). In the second step, the Can-Derem step dissolves the nickel and iron oxides, releasing most of the radioactive material into solution.

Con Edison has already used AP/Can-Derem on three occasions to rid Indian Point 2 of some radioactivity. The method was applied in 1989 to the regenerative heat exchanger, in 1991 to the chemical and volume control system, and in 1993 to the residual-heat removal system. This repeated decontamination has eliminated over 110 man-rems of radiation



▲ In the two-step AP/Can-Derem dilute-solvent process, chromium dioxide deposits in the oxide layer are first oxidized to less tenacious CrO_4 by an alkaline permanganate solution. Then the proprietary Can-Derem process is able to dissolve the oxide layer (containing primarily nickel and iron oxides), releasing most of the radioactive material into solution.

Defining terms

Chemical and volume control system: a support system for the reactor coolant system, whose fluid flow rates it regulates in order to control water chemistry.

Pressurized-water reactor: a reactor in which the primary cooling water is kept under enough pressure to prevent it from turning into steam.

Pressurizer: a cylinder containing water and nitrogen to stabilize pressure in the reactor coolant system.

Primary auxiliary building: where support equipment for the reactor coolant system is housed, adjacent to the containment for the reactor fuel.

Reactor coolant system: the system of equipment that conveys heat from the nuclear reactor core to where it can do useful work; also called the full primary system.

Residual-heat removal system: a support system for the reactor coolant system, whose temperature it controls by means of two heat exchangers.

Spinel: one of a group of minerals with the general formula AB_2O_4 , where A may be magnesium, ferrous iron, zinc, or manganese, or a combination of them, and B may be aluminum, ferric iron, or chromium.

exposure, while increasing productivity and saving about \$10 000 per man-rem for a total of about \$1 100 000.

In 1987, Con Edison spearheaded a program to determine whether the same processes, based as they were on dilute chemical solvents, were also qualified to decontaminate the full primary system. EPRI, Eserco, and 10 other utilities that own pressurized-water reactors also took part in the program, as did Westinghouse Electric Corp.

Two processes were picked as candidates: AP/Can-Derem and AP/Lomi (low oxidation-state metal ion). Both had been in frequent use for reducing the radioactivity of individual components but neither had been applied before to entire systems.

The processes alternate oxidation and dissolution reactions. The number and sequence of the steps depends on the assortment and concentration of chemicals to be found in the deposited oxide layer, and also on the relative effectiveness of each step. Alternating the steps is the speediest way to dissolve the metal-oxide layer.

With the AP/Can-Derem approach, a five-step procedure of three dissolutions and two oxidations has been found effective. The oxidation step is carried out at 90 °C for up to 12 hours, and the dissolution step is performed at 115 °C for up to 24 hours. The five-step total, including cleaning, occupies five outage days. It is expected to yield a decontamination factor (ratio of radiation field strength before decontamination to the strength after) of five or more.

One important question is, "For how long will the benefits of decontamination last?" Although no precise answer can be given, we estimate that significant benefits may last for as many as five operating cycles, or 10 years, at Indian Point 2. The exact length of time will, of course, depend on the rate at which the system is recontaminated.

In the AP/Can-Derem process, the decontamination solution is regenerated for reuse, with the isotopes removed by the acidic solution being captured by a cation-exchange resin. Decontamination is ended by isolating the cation resin and employing a mixture of cation and anion resins to clean up the system. The anion resin removes the chemical reagents, while the cation resin removes any vestiges of dissolved metal.

Qualifying exams

A test program was needed to qualify AP/Can-Derem and AP/Lomi for the full reactor-coolant system. But first, the conditions, parameters, and criteria for the test program itself had to be established. To this end, a detailed study was undertaken of the primary system of the



WESTINGHOUSE ELECTRIC CORP.

◀ This test loop constructed at Westinghouse Laboratories contains material specimens of the same alloys as the Indian Point 2 reactor coolant system. It was operated with the same chemicals and under the same conditions that would prevail later during the plant's decontamination. Examining the material specimens afterwards gave the test engineers confidence that the AP/Can-Derem process could be safely applied several times to an operating plant without compromising its integrity.

pressurized-water reactor located at the Indian Point 2 plant.

An early finding of the study was that a plant system based on pressurized-water reactors can itself be used to control processes for dissolving contaminants on the full primary system. All the plant needs is the support of a temporary decontamination system for feeding in the chemicals and for receiving and processing the waste.

Another conclusion was that even although decontamination with the fuel removed from the reactor sharply reduces plant-operating costs, still sharper cost reductions would result with the fuel left in place (because the surfaces of the fuel elements would be decontaminated, too). For the first full primary system decontamination, the fuel will be removed. With experience, though, it will probably be left in place during decontamination.

Extensive surveys were conducted to compile a complete list of the materials that would be exposed to the chemical solvents. Then a series of tests was designed to address all possible issues for each material under the flow and chemistry conditions expected in the reactor-coolant system. Upwards of 250 specimens of more than 80 materials were tested.

The tests were directed by Con Edison but carried out by Westinghouse Electric. A team from the company's Nuclear and Advanced Technology Division, Pittsburgh, took samples of all the alloys in the plant. Then it built a test

loop through which the same chemicals could flow at the same concentrations, temperatures, and pressures, and for the same lengths of time as would be experienced during the actual plant decontamination [see photograph above].

Tests were further performed with the chemical concentrations and temperatures raised by about 20 percent. These "fault" conditions made the tests more corrosive and demonstrated that the process had a comfortable safety margin—that is, it could safely handle unexpected excursions in conditions.

The tests were designed to establish a technical basis for decontaminating the plant at least three times during its remaining life. Engineers at Westinghouse evaluated the test results in cooperation with a utility steering committee. These evaluations were compiled, recommendations were made for application in the field, and a safety assessment was performed.

On behalf of the program sponsors, Westinghouse submitted reports on the successful qualification of the two processes to the Nuclear Regulatory Commission. That body has reviewed the reports and approved the processes' use by utilities, who will apply the technology at their sites. The review concluded that the decontamination could be performed successfully without a license amendment, and it provided certain guidelines.

Both of the candidates were approved by the Nuclear Regulatory Commission,

but application considerations persuaded Con Edison to pick AP/Can-Derem. The process offers on-line control features and cuts back on waste because of its regenerative nature. For Indian Point 2, AP/Can-Derem offered lower cost and less waste than AP/Lomi for the same relative effectiveness.

Status at Indian Point 2

To date, things have gone well. Preparations for the decontamination of the full primary system were finished ahead of schedule. In fact, the equipment built for the project completed functional tests at the facilities of Vectra Technologies, Richland, Wash., which is in charge of the actual work of the decontamination.

By design, the system will have the smallest possible impact on the plant. Decontamination chemicals, demineralizer resins, and clean water for resin sluicing will be supplied from equipment placed outside the plant buildings. The demineralizers themselves, though, will be temporarily located inside plant buildings at Indian Point Unit 1 (which was shut down in the early '70s) in order that the radioactive material removed will be shielded. (New York State has yet to identify a final repository for the radioactive waste.) In addition, a number of minor, but temporary, modifications will have to go into effect. For example, low-pressure seals associated with the instrumentation in the reactor's core will be upgraded to cope with the higher operating pressure expected during decontamination.

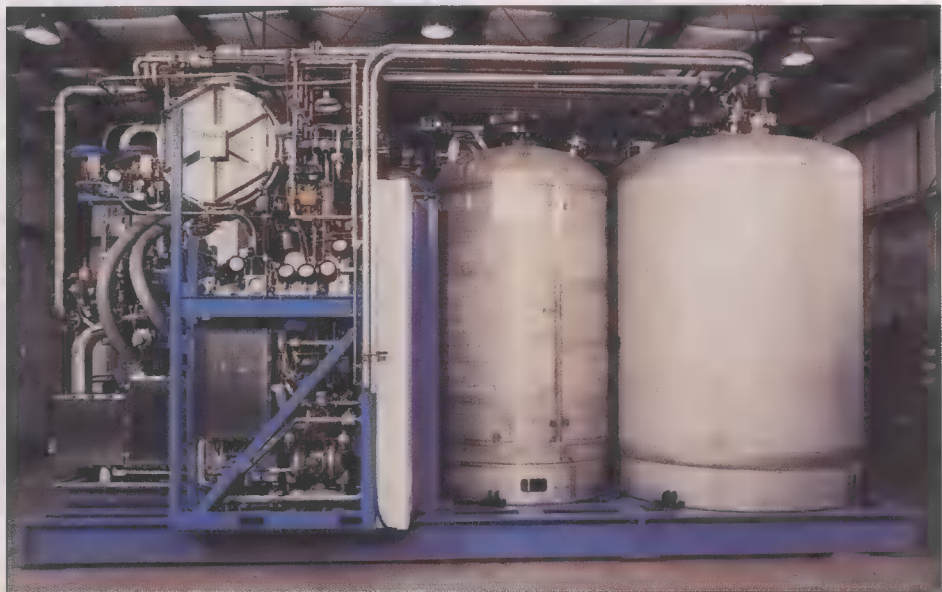
Most of the in-plant decontamination system is being housed in the Indian Point 2 primary auxiliary building, in a small room that normally provides temporary storage for waste [see photo, this page]. During the clean-up process, the in-plant system will be controlled remotely from an adjoining building. That room also communicates with the plant's central control room, so that the clean-up effort can be coordinated with plant operation.

As for injecting chemicals into the primary system and removing water from it for cleansing, the means here will be the Indian Point 2 plant's system for removing residual heat. This system has been equipped with connection points for the temporary decontamination support system. From the heat removal system, solvents will travel through the reactor coolant system to the Indian Point 2 chemical and volume control system. One reactor coolant pump would suffice to circulate the solvent, but up to three may be

brought on line for uniform decontamination of the reactor coolant loops.

The solvents require a certain working temperature, and the coolant pumps generate enough heat for this purpose. In the mean time, the heat removal system's heat exchangers will balance the primary sys-

tem. More immediately, participants in the on-going Indian Plant 2 demonstration will gain first-hand experience of the decontamination process and will come away from it with operating results, specifications, and safety evaluations. Consequently, they should be in an excellent



▲ It's a little tight, but most of the in-plant equipment needed for the decontamination process fits quite nicely into this small room in the Indian Point 2 primary auxiliary building. During actual decontamination, the process is controlled from an adjoining building.

tem temperature. Once decontamination is complete, the resins will be pumped to containers for temporary storage on site.

Economic benefits

We estimate that full-system chemical decontamination could cut the costs of the utility industry as a whole by several hundred million U.S. dollars over the next 10 years. The amounts saved would vary from plant to plant, depending on age, radiation field strength, and maintenance and equipment replacement activities. At a typical pressurized-water reactor having a cycle exposure of 290 man-rems, full primary system decontamination could bring about a reduction of 200 man-rems. Further savings will flow from reductions realized in outage time, materials, and radioactive waste. (A lower-radiation environment warrants less protective equipment for workers and produces less radioactive waste.)

In the course of five operating cycles, a net savings of approximately \$35 million could be achieved. In addition, if the advancement is properly publicized, the lowering of radiation levels should improve the image of the nuclear industry and make the public at large more aware of the industry's continuing pursuit of plant performance enhancements.

position to decontaminate their plants at much lower cost.

The economics of the matter are worth stressing, as full-system decontamination can in the future be expected to become a vital part of the operation and life expectation of nuclear power plants.

About the authors

Stephen A. Trovato (M), principal mechanical engineer, is a licensed mechanical engineer who has worked in the power industry for 15 years. For the last eight, he was a research project manager directing nuclear research for Con Edison and coordinating the research consortia for the decontamination projects. His telephone number is 212-460-2090.

John O. Parry, project manager, is a certified health physicist who has managed radiological engineering and protection groups at Con Edison and other utilities for 20 years. He is the project manager for the full primary system decontamination demonstration. He may be reached at 914-734-5038.

James M. Burger, program manager, has a doctorate in physics and manages the nuclear power program for the Empire State Electric Energy Research Corp., New York City, where he has worked for the past 19 years. His number is 212-302-1212.

THE ELECTRONIC MOTORIST

Now is the time for novel technology—navigation gear, night vision, fuzzy logic, and more—to come to the car driver's aid

IMAGINE CROSSING THE CAR LOT LATE AT NIGHT to a welcome from your automobile: the doors unlock, the engine starts up, the heating system warms the interior to just the temperature you like. As you get in, you state your destination aloud—and the liquid-crystal display on your dashboard takes note. It lights up colorfully with, alas, the news of a water-main break downtown, but it helpfully suggests another route home.

A synthetic voice steers you along roads and across intersections through unfamiliar neighborhoods. Suddenly there's a popping sound and an indicator starts flashing, telling you your left front tire has lost pressure—you've got a flat. As you pull over to the curb, some unsavory-looking types start strolling toward you. But the push of one button sends a call for police assistance, and the push of another alerts a nearby service station to your emergency. Both calls state your exact location.

Soon, you are on your way out of town. Peering at the unlit country road, you switch on your infrared night vision system. Instantly everything is identifiable. How could you ever have managed without it?

This is not a science fiction scenario set far in future, but a realistic view of the kinds of electronic capabilities ordinary cars will acquire in the next five years. And as the automotive industry gears up to make cars safer and more convenient for drivers and passengers, electronics companies stand to gain windfall profits.

In short, in the buoyant field of automotive electronics, emerging technologies should more than offset market saturation by maturing products. Revenues worldwide could reach US \$15 billion in 1994, \$20 billion by 2000, and \$28 billion by 2005, concluded a study released in October 1994 by Siemens Automotive Corp. and *Ward's Auto World*, of Auburn and Southfield, Mich., respectively. The same study predicted that on average the cost of electronics per car would hit \$1500–\$1749 this year and as much as \$2249 by 2000.

This *IEEE Spectrum* report focuses on some technological new-

comers likely to promote strong growth in automotive electronics. The material has been culled in the main from two conferences and one book: January's Consumer Electronics Show, October's International Congress on Transportation Electronics (Convergence), and the recent *Automotive Electronics Handbook* [see To Probe Further, p. 46].

Getting there

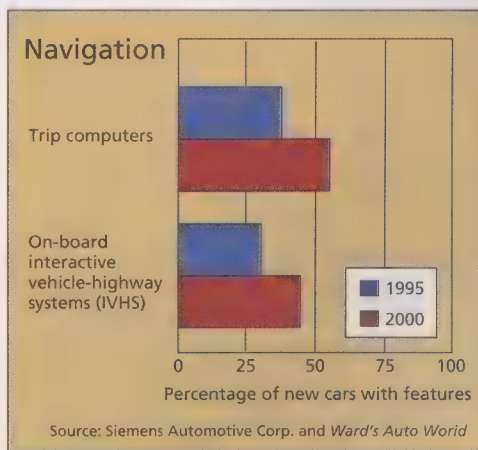
Systems that help the driver navigate are booming. They got their start in the early 1980s, but Japan was years ahead of the West in actually getting to market, said Tsuneo Takahashi, a Honda R&D Co. engineer, speaking at the October congress.

First off the production line was Toyota Corp.'s autonomous navigation system for cars. Called Electro Multivision, it went on sale in Japan in 1987. By 1994, around 500 000 had been sold, according to the auto navigation pioneer, Robert L. French, president of Robert L. French & Associates, Fort Worth, Texas. Yet in that same year—1994—navigation systems from original-equipment manufacturers (OEM) were just being introduced to the general public in the United States and Europe.

What goes into a vehicular navigation system today? Almost all of them include dead reckoning, writes French in the *Automotive Electronics Handbook*. That is, they count wheel revolutions from a starting point and factor in turns with gyros to determine the car's position on a map. Whereas map matching is the main positioning technology, state-of-the-art systems also include a receiver for the global positioning system (GPS), now that the latter's satellite constellation is fully operational. As French points out, map matching and route guidance demand digital road maps.

Navigation systems also lean on mobile data communications for traffic and travel information in general. Essential to a typical navigation system, writes French, is a location sensor, to provide absolute position if dead

RONALD K. JURGEN
Contributing Editor



reckoning with map matching should fail [see diagram below].

Since its 1987 launch, Toyota's Electro Multivision system has undergone many refinements. Today, using both dead reckoning and digitized maps stored on CD ROM, it displays colored icons denoting the vehicle's present position on a raster-scanned cathode-ray-tube (CRT) screen. The map database includes the whereabouts of facilities of interest to motorists. Newer versions of the system also include a GPS receiver and a color liquid-crystal display (LCD), rather than a CRT screen.

In 1991, a routing feature was added to the system, French reports. It calculates a route to specified destinations and highlights it on the LCD map. In the most recent model, synthesized-voice instructions guide the motorist along the route, and a rear-vision camera using charge-coupled devices (CCDs) produces images that are shown on the LCD screen, while the navigation features have been integrated with the car's entertainment systems.

Elsewhere, in the United States and Europe, new systems strive to differentiate themselves through price and technology. They range from stand-alone \$2000-and-up systems to no-frills systems that can sell for \$500 because they exploit a car's compact-disc (CD) changer and audio system.

At the low end are voice-activated systems introduced at the January Consumer Electronics Show. The basic system was developed by Amerigon Inc., Monrovia, Calif. It has no displays but uses voice recognition and synthesis in conjunction with a car's audio system. A computer module interfaces with the car's CD player, which may also have a CD changer, to read CD-ROM map discs.

A synthesized voice prompts the driver to speak the car's present location and the desired destination into a microphone. The system then analyzes the CD-ROM map, calculates the best route, and issues step-by-step synthesized-voice instructions through the car's audio system. Drivers need never take their eyes from the road. Amerigon claims that its technology, the fruit of over eight years' work, is not fazed by any of many different U.S. dialects or by foreign accents.

The new products based on Amerigon technology and introduced in January included systems from Alpine Electronics of America, Clarion Sales, Fujitsu Ten, and Kenwood USA. To describe just one, the NVA-N100 system from Alpine Electronics of America Inc., Torrance, Calif., is a \$650 option for Alpine's Ai-NET audio network. It operates from a CD six-disc changer (\$550), but it could be adapted to work with other changers as well.

To activate the system, the driver says "navigator" into the microphone. The CD

changer then automatically selects the CD map disc. After deciding on the landmarks, addresses, or cross streets to be used as starting or destination points, the driver enters them into the system by spelling their names aloud. The synthesized voice then responds with directives, street by street and turn by turn, to the requested destination.

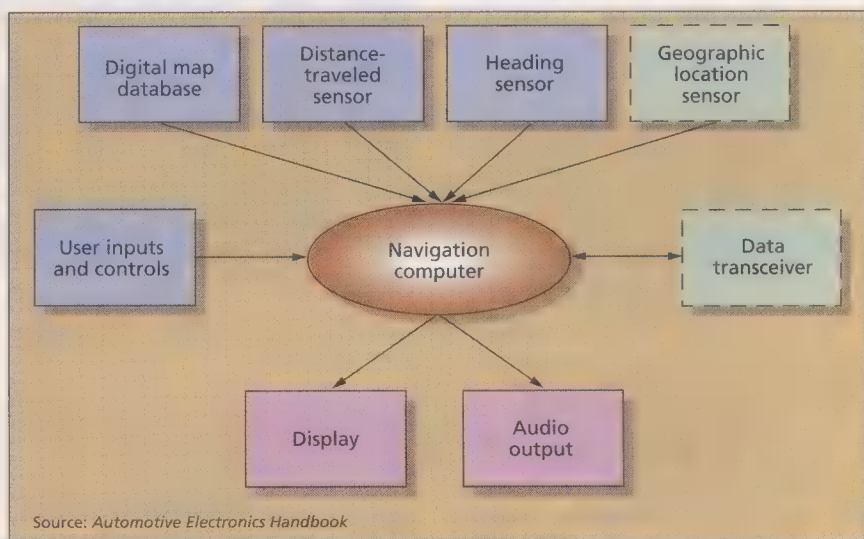
More established navigation systems, such as the one designed for OEM applications by Blaupunkt of Robert Bosch GmbH, Hildesheim, Germany, use displays for driver guidance. The Berlin RCM 303A mobile information center puts many controls at a driver's fingertips—those for the radio, CD changer, cassette player, telephone, and navigation system controls. A nine-button, 10-cm-diagonal LCD color monitor and integrated tuner

player could be loaded with data disks for the country desired.

The suggested retail price of the system, including its entertainment and navigation components, is 11 000 DM (about US \$7150). The radio alone is 7000 DM (\$4550). By this summer, the navigation system is expected to be available without the radio for 4000 DM (\$2600).

A U.S. display-based system was tested by General Motors Corp., Detroit, Mich. For one year, ending in 1993, GM equipped 100 cars with a prototype navigation system called TravTek for an Orlando, Fla., field trial. The cars were made available either through Avis Rent A Car or by assignment to local drivers, and the American Automobile Association operated an information and services center for the test.

Travtek was a veritable tour guide: it



▲ A typical vehicle navigation system comprises a wide range of electronic subsystems.

technology are part of the package.

The driver operates the center's navigation system by selecting from a menu on the LCD screen. The system then calculates the fastest route between two locations. Unusually, the system makes no use of street maps, but shows route recommendations symbolically, on the same color screen as is used to control the car radio. An arrow indicates the best direction to take at the next intersection [see middle photo, opposite], and a computer voice informs the driver, in advance, when to make a turn. The system computes the distance to a turn and creates a shaded bar graph that dwindles as the vehicle nears the intersection where the driver should turn.

Currently, the Blaupunkt system is programmed with information covering over 650 000 km of roads in Germany alone. In the future it could be linked with a receiver for GPS signals and then could operate in other countries as well. A CD-ROM

doled out facts on navigation, route selection and guidance, real-time traffic status, local yellow pages and tourist lore, and cellular phone service. Based on dead reckoning and map matching, the experimental system superimposed vehicle location on a map display screen that highlighted suggested routes. A synthesized voice also proposed possible routes. Traffic information received by radio link from a center in Orlando was utilized to recommend the least congested routes.

A similar system is already on the U.S. market. Telepath 100, introduced by Delco Electronics, Kokomo, Ind., is a low-cost system that supplies directions to, and the decreasing distance from, selected destinations. Displaying special graphics, the system employs a GPS receiver, a dead-reckoning system for use when GPS is not available, and a map database from Etak Inc., Menlo Park, Calif. A directory gives the driver access to a listing of restaurants, hotels, and other travel destinations.

Telepath is being marketed through automobile dealers as an aftermarket product in the \$800-\$1000 range.

Delco said that future enhancements of Telepath 100 could include a one-touch Mayday transponder, traffic information, and way-point guidance, not to mention a head-up display for information and one-touch dialing of travel destination.

Owners of Oldsmobile 88 cars who are willing to spend rather more might consider Guidestar. This navigation-information system has been available as an option for their automobile in California since September, following a successful pilot run by Avis Rent A Car in San Jose. The system delivers accurate and immediate information and instructions from a LCD screen attached to the instrument panel [see photo, bottom right]. It was developed for Oldsmobile by Delco Electronics, Zexel USA, and Rockwell Automotive Electronics.

The system has four components. Its dash console supports seven input keys and a 6.3-by-8.2-cm active-matrix color LCD screen. Its compact GPS antenna is mounted on the rear package shelf. Its computer is mounted in the trunk. And its wire harness interconnects everything.

The computer monitors four channels of information. Two channels scan signals, one from the GPS antenna and the other from an internal gyroscope (to quantify cornering maneuvers). The other two check on the vehicle's speed and back-up lamp voltage (to sense direction of travel). The vehicle's location is pinpointed by advanced dead-reckoning techniques and GPS satellite inputs.

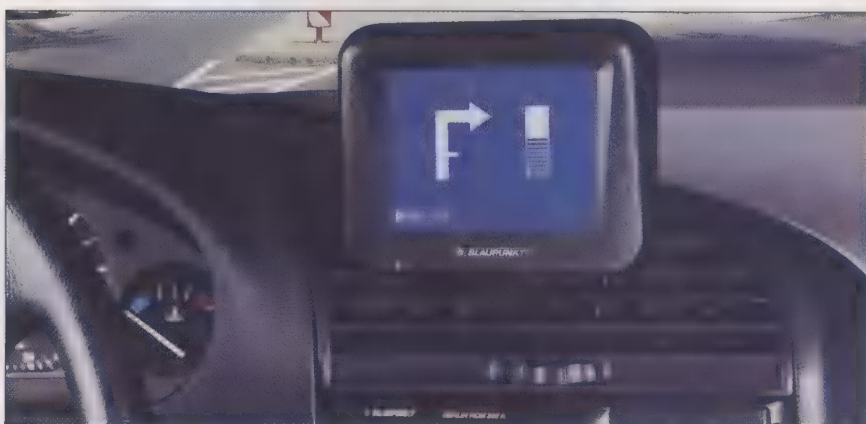
To start up the navigation-information system, the driver touches one key and is then prompted, through a menu screen, to enter details of the desired destination. Those particulars may be an address, a road intersection, a place of public interest, or even the destination of a previous journey held in the computer's memory. The system also allows the driver to select a preferred routing method, using free-ways, for example, whenever possible.

Once the destination has been set, the driver guides the cursor and presses an enter key. In seconds the on-board computer, which is constantly aware of the vehicle's current location, calculates the most efficient route for the trip, and sends the LCD screen a map of the area highlighting the route in color. Once the trip begins, the distance to and direction of each turning maneuver is displayed on-screen in bold graphics. A voice prompt advises when a turn is approaching so that the driver's attention will not be diverted from the road. If a turn is missed or cannot be taken because of road construction or traffic congestion, the system reroutes the journey at the touch of a single key.



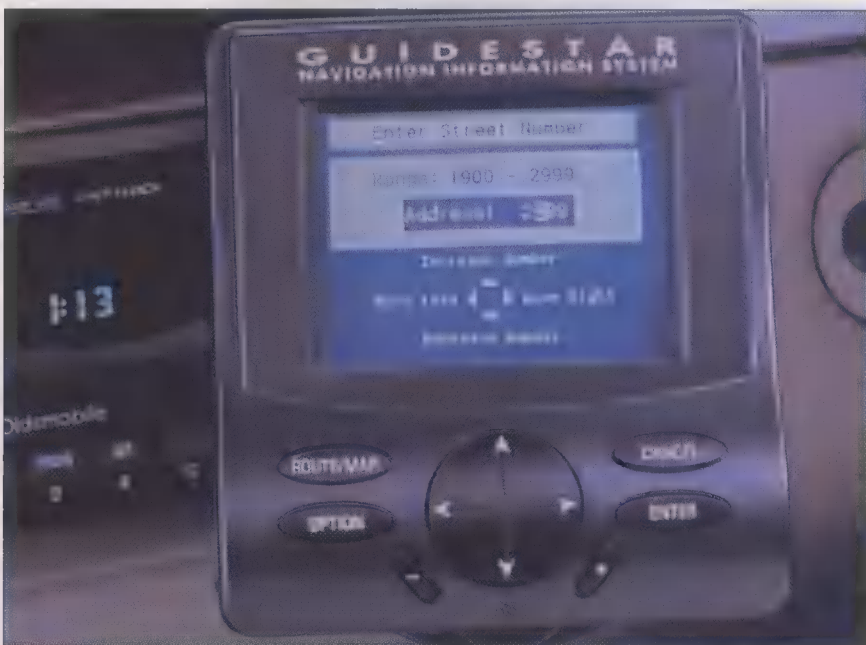
SONY ELECTRONICS INC.

▲ Sony Electronics' NVX-F160 mobile navigation system utilizes the global positioning system in combination with maps on CD-ROM discs developed by Etak Inc. It also includes information from Fodor travel guides on restaurants, hotels, stores, and places of entertainment.



ROBERT BOSCH CORP.

▲ The Bosch-Blaupunkt vehicle navigation system from Germany prompts the driver with a turn signal and a bar graph that gets steadily shorter as the vehicle approaches a desired turn. A voice prompt tells the driver when the turn is near.



OLDSMOBILE

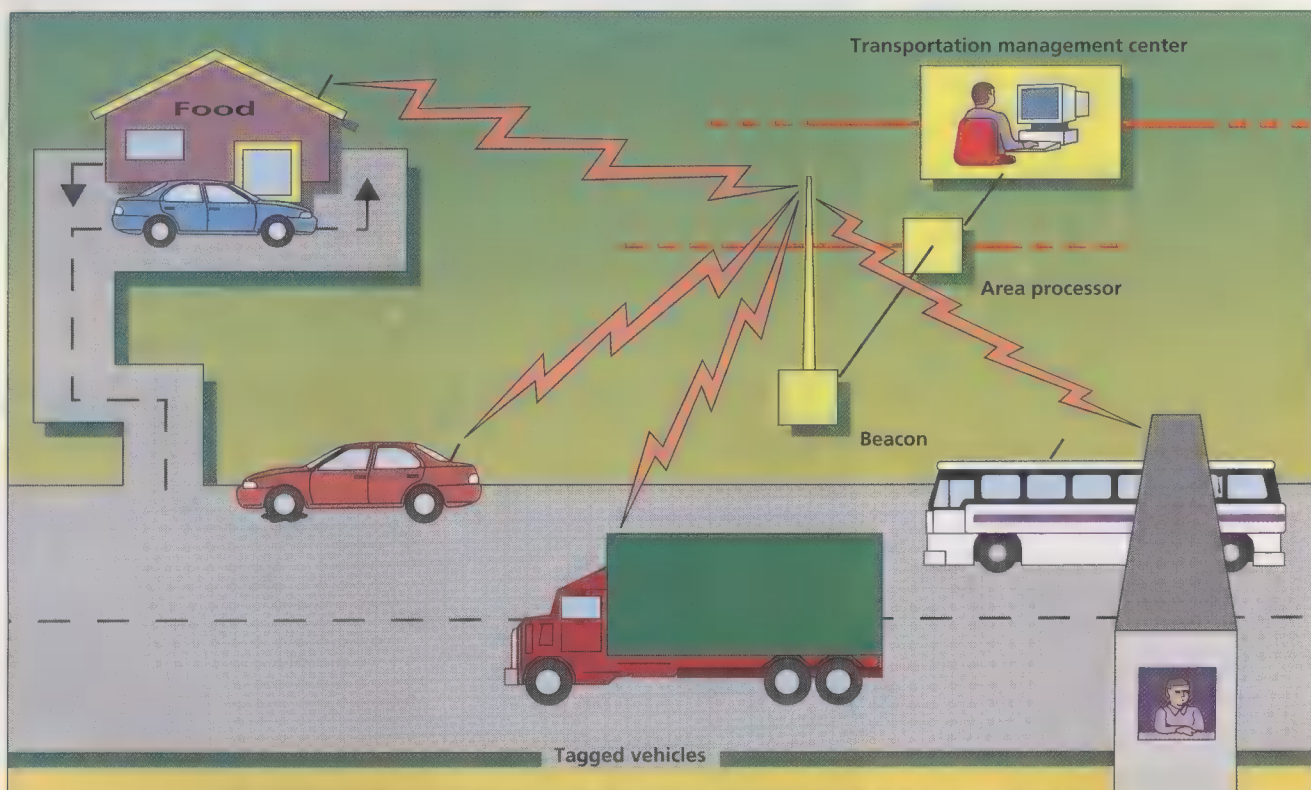
▲ Oldsmobile's Guidestar navigation system is mounted in the dashboard but is removable. The display shows a destination menu, routing preference, street number input, and turn-by-turn route guidance.

The manufacturer's suggested retail price for Guidestar is \$1995, including its installation and the California database cartridge that covers the Las Vegas metro area. Oldsmobile introduced the system in Michigan, Illinois, and Indiana

late last fall. Mapping cartridges covering Florida and Georgia were available by the end of last year. Cartridges for the areas covering Washington, D.C., Maryland, and Virginia, and for New York, New Jersey, Rhode Island, and Connecticut

will be on the market early this year. The system is scheduled to be available nationally in the first quarter of 1996.

For the aftermarket, one of Guidestar's developers, Rockwell Automotive Electronics, Troy, Mich., has introduced basic-



Intelligent transportation system (ITS) user services

Travel and commercialization management

- ▶ En-route driver information
- ▶ Route guidance
- ▶ Traveler service information
- ▶ Traffic control
- ▶ Incident management
- ▶ Emissions testing and mitigation

Travel Demand Management

- ▶ Pre-trip travel information
- ▶ Ride matching and reservation
- ▶ Demand management and operations

Public Transportation Operations

- ▶ Transportation management
- ▶ En-route transit information
- ▶ Personalized public transit
- ▶ Public travel security

Electronic Payment

- ▶ Payment services

Commercial vehicle operation

- ▶ Electronic clearance
- ▶ Automated roadside safety inspection
- ▶ On-board safety monitoring
- ▶ Administrative processes
- ▶ Hazardous material incident response
- ▶ Fleet management

Emergency management

- ▶ Notification and personal security
- ▶ Vehicle management

Advanced vehicle control and safety systems

- ▶ Longitudinal collision avoidance
- ▶ Lateral collision avoidance
- ▶ Intersection collision avoidance
- ▶ Vision enhancement for crash avoidance
- ▶ Safety readiness
- ▶ Pre-crash restraint deployment
- ▶ Automated highway systems

Source: ITS America

ly the same system, called PathMaster, for a \$2495 suggested list price. Another developer, Zexel USA Corp., Farmington Hills, Mich., has its own version called Navmate, which it has licensed to Rockwell International and Siemens AG.

Other top-end navigation systems launched at the Consumer Electronics Show came from Sony and Pioneer. The \$2995 NVX-F160 from Sony Electronics Inc., Park Ridge, N.J., uses GPS technology and an Etak map database to provide directions and detailed information illustrated with sound and photos [see top photo, p.39]. It includes 5800 listings from Fodor's, a publisher of travel guides.

The \$2850 GPS-X77, introduced by Pioneer Electronics USA Inc., Long Beach, Calif., stocks 120 000 information listings in 90 categories. Although similar technologically to the Sony system, the Pioneer system provides less detailed listings, but more of them.

A different approach to navigation systems has been taken by SEI Information Technology, Plymouth, Mich. Its technology, EnRoute, gives travelers information through wireless data networks. EnRoute

delivers step-by-step navigation data as well as route guidance between any two points in a region. While loaded databases are installed in the car, users also have access to remote terminal query systems. The driver, for example, can use a cellular telephone to call up the remote server for real-time, updated travel information—data that can be downloaded into a laptop computer or personal digital assistant.

Smart transportation nearer

Navigation systems are just one component of intelligent transportation systems (ITS). In the United States, this ITS group so far includes advanced systems in traffic management, travel information, vehicle control, commercial vehicle operations, and public and rural transportation. Indeed, ITS is expected to create a \$200 billion industry over the next 20 years, according to the Intelligent Transportation Society of America (ITS America), a nonprofit association located in Washington, D.C.

To ensure ITS flourishes, the U.S. Department of Transportation (DOT) and ITS America are working with many orga-

nizations at national and international levels. But decisions on what ITS will comprise and how it will be used will be made primarily by state, regional, and local agencies—with plenty of input from transit and commercial fleet operators, consumers, and public interest groups.

Already some of the interested parties have participated in a program-planning process. Its goal: to identify a number of capabilities or user services that, if deployed, will collectively meet ITS goals. Currently, there are 29 user services that fall into seven general areas [see block diagram, opposite].

An integrated ITS system is a key aim of the program. So DOT set up the National ITS Architecture Development Program, with a view to completion of the development by mid-1996. The architecture is to describe how system components will interact in order to meet system goals. An explanation of how the system operates will be included, as will what each component of the system does and what information is to be exchanged among the components. The structure is to be flexible enough to accommodate different levels of implementation,

Vehicle location system alternatives

Location technology	Accuracy	Coverage	Operating frequencies	Update interval	Mobile equipment cost
Global positioning system (GPS)	<100 meters	Global	1227 and 1575 MHz	1 second	US \$400 ^a
Mobile communication satellites	>100 meters	Variable	137 MHz to 14.5 GHz	Variable (occurs every transmission)	None (if communication terminal is already in vehicle)
Global maritime distress and safety systems (GMDSS)	10–20 or 3–5 km	Global	121, 243, and 406 MHz	Hours	\$200 (10–20 km) or \$1000 (3–5 km)
Argos	150 meters (with highly stable oscillators)	Global	137 and 401 MHz	Hours	Varies (Custom-built hardware)
Loran-C	<0.8 km on land	Continental United States	100 kHz	>10 seconds	\$200–\$400
Omega	>>1 km	Global	10.2, 11.33, and 13.6 MHz	>10 seconds	\$30 000 ^b
Lojack	Line of bearing available to ±11%	65-km ² box, centered on Lojack-equipped police cruiser	173.75 MHz	Not applicable	\$595 ^c
Cellular-phone-based systems	Within a cell (46 meters at 8 km with special directional finder)	Cellular system area of coverage	824–849 MHz	Variable (occurs every transmission)	None (if cellular phone is already in vehicle)
Dead reckoning	<2% of distance traveled	Global	Not applicable	1 second	\$50–\$5000

^a Price falls to \$100 for the Tidget device, which samples satellite RF signals for a distant base station to use in computing vehicle location.

^b Advent of more accurate systems has driven pure Omega systems from market; cost represents Omega hybrids (with GPS).

^c Not modified for automated collision notification (ACN).

Source: Proceedings, Convergence '94



PARALLEL-VECTOR SUPERCOMPUTERS ENTER THE TERAFLUPS ERA

Now that supercomputers have comfortably settled on the GigaFLOPS plateau, the next target is TeraFLOPS – one trillion (10^{12}) floating-point operations per second. NEC has become the first to enter the TeraFLOPS era with the introduction of new parallel supercomputers.

Our SX-4 Series features a balanced, scalable, parallel-vector architecture that spans a 1,000-fold performance

range from one GigaFLOPS to one TeraFLOPS. The SX4 Series includes five compact models with one to four processors (comparable to high-end UNIX computational servers); five single-node models with four to 32 processors; and six multi-node models with 16 to 512 processors.

The SX-4 Series features extraordinary price-performance. Instead of costly and high-power ECL chips,

the SX-4 Series uses high-speed, low-power CPUs implemented with a 0.35-micron CMOS process. Further progress comes from the use of 4Mb synchronous SRAMs for the main memory. The use of low-power CMOS chips permits air-cooling for all models. This substantially reduces installation costs and complexities.

The first of the new supercomputers to enter service is an eight-processor, 16 GigaFLOPS model for the Atmospheric Environment Service of Canada. It is expected to deliver a fourfold increase in the accuracy of coast-to-coast weather forecasts.

DOMSAT MOBILE PHONE SERVICE IN AUSTRALIA

For countries which spread across vast territories, domestic satellites are the key to mobile telephone networks with nationwide coverage. Optus Communications of Australia started a new satellite-based mobile communications service.

Using Optus domestic satellites, the Optus MobileSat® service extends coverage across the entire Australian continent and up to 200km out to sea. Existing cellular phone networks cover only urban areas, which make up about 3% of Australia's land mass.

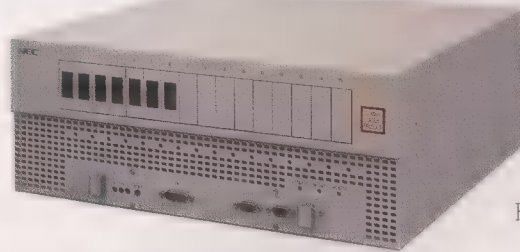
MobileSat provides high-quality, digital voice, facsimile and data services for people working in remote areas. Previously, HF radio was the main means of long-distance communication in such areas. MobileSat telephones consist of a handset, L-band transceiver measuring 32 x 35 x 12cm, and 96cm rod antenna.

NEC Australia worked with Optus for four years on the development of the new service. NEC supplied MobileSat telephones and complete systems for the MobileSat Network Management Stations in Sydney and Perth. These two stations handle Ku-band communications links with the Optus satellites. They also provide call management, call records, and interface with the Public Switched Telephone Network.

DESKTOP ATM SWITCH FOR LANs

For users who need a broader bandwidth capable of transmitting all kinds of information – voice, video and data – workgroup LANs based on ATM technology are an ideal solution. NEC offers a high-performance, desktop ATM switch for workgroup LAN applications.

Our ATM Switch Model 5 features aggregate throughput of 2.4Gbps. It has ports for up to 16 line interfaces



which accommodate ATM 100M/140M MMF, OC-3c/STM-1 (155Mbps) MMF/SMF/UTP-5, DS3 (45Mbps) and E3 (34Mbps). Each port has a 1,000-cell input buffer to minimize cell-loss caused by traffic bursts. The Model 5 supports both permanent and switched virtual connections and performs 4,096 virtual connections per interface.

The Model 5 uses an Expandable ATM Output-Buffer Modular Switch (XATOM) which is implemented in a custom-designed CMOS chip set. XATOM efficiently handles both constant-bit-rate and multicast traffic. XATOM's back-pressure control algorithm provides multi-level traffic control including congestion control, priority control and traffic shaping.

The desktop ATM switch measures 435 x 420 x 165mm. It complies with requirements by ITU-T, ANSI, Bellcore, ATM Forum and ETSI.

1Mb CMOS SYNCHRONOUS SRAMs

To perform up to their full potential, today's supercharged microprocessors need cache memories that match their blazing speed. Conventional SRAMs are too slow. BiCMOS SRAMs have the speed, but they are expensive and power-hungry.

NEC's new 1Mb CMOS SRAMs use synchronous technology with burst counters to break conventional speed limits. Our pipelined 32K x 32 device features 8ns access time. Two chips

make a 66MHz-256KB cache for the Pentium™ or Power PC™. Four chips make a 512KB cache for high-end PCs or servers. Interleaved or linear burst is pin-selectable.

NEC offers a wide choice of 1Mb Synchronous SRAMs. Pipelined devices provide access speeds of 8/10/12ns for 66/60/50MHz cache. Non-pipelined devices offer 12/13/14ns speeds for 50MHz cache. All our Synchronous SRAMs operate on 3.3V and come in 100-pin plastic TQFPs.

NEC

Fuzzy logic on the road

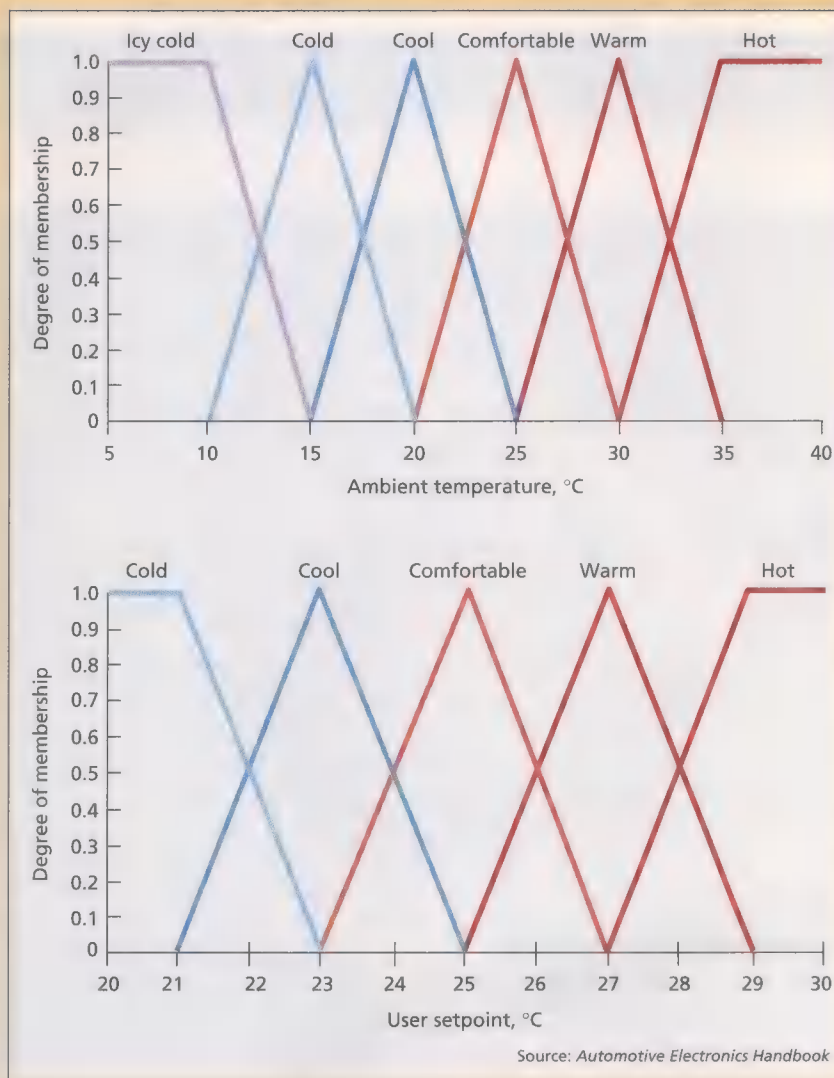
Expectations are that fuzzy logic will be a boon to automotive electronics. It has already had a degree of success in cruise control and automatic transmission systems. But its type of reasoning promises far wider application. Potential applications are in controls for car speed, engines, anti-lock brakes, and heating, ventilation, and air conditioning.

Three situations in which fuzzy logic can shine were outlined by Shinichi Sakaguchi, a Honda R&D Co. engineer, at the Convergence congress in October. One situation would arise when the system to be controlled confronts environmental conditions that are complicated and difficult to express mathematically. Another could be when the characteristics of the system change with such factors as temperature, despite the fact that the system to be controlled remains constant. A third would be the existence of multiple control objectives.

Two fuzzy-controlled automatic transmission systems—the Mitsubishi Invecs and the Honda Prosmatec Type F—served Sakaguchi as examples.

The Mitsubishi system adds fuzzy control to a conventional technique, wrapping up the driver's intentions, vehicle status, and road conditions into a final judgment. Based on that judgment, the system can select from a so-called flat mode (even terrain), one that climbs a curvy hill, one that climbs a straight hill, or one that goes downhill. A map for each mode decides on throttle opening and gear position according to vehicle speed, as is done with the usual type of automatic transmission.

The Honda system goes further replacing conventional techniques entirely with fuzzy control. Fuzzy rules in the IF-THEN format serve exclusively to determine gear selection. In addition to vehicle speed and throttle information,



inclination and other data are used. The Fuzzy inference determines when the driver intends to decelerate.

Heating, ventilating, and air-conditioning a car is another likely fuzzy logic application, described in detail in the *Automotive Electronics Handbook*. Here,

subjectivity calls the tune, explains contributor Richard J. Valentine, principal staff engineer, Motorola Semiconductor Products Sector, Phoenix, Ariz. The system designer would define the input conditions and desired output subjectively. A car's inside temperature of, for

various system designs, and system evolution over time.

This ITS alternative architecture program is proceeding in two phases. During Phase I, now completed, selected teams developed an architectural concept and made a preliminary evaluation of it. The goal of Phase II is to develop a single national consensus architecture that will allow all user services to be interrelated.

In September 1993, DOT selected four teams to develop ITS architectures based on a 20-year (1992-2112) implementation plan that addresses the current set of user services [see figure, p. 40]. The teams were led by Hughes Aircraft, Westinghouse

Electric, Loral Federal Systems, and Rockwell International.

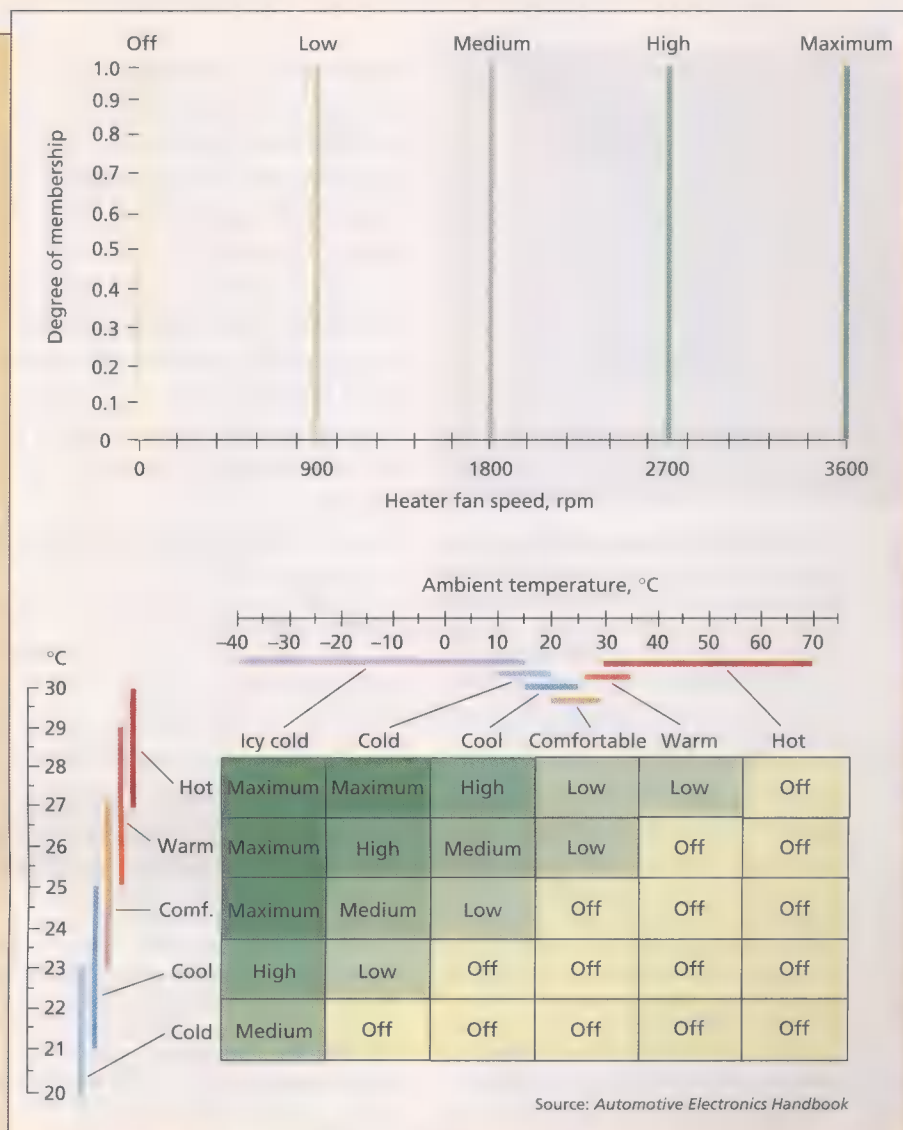
Each had its own angle on the program. The Hughes team worked on a tag/beacon approach to vehicle-roadside communications. Every vehicle was to be fitted with electronic transponder tags so that drivers might pick up on the traffic advisories provided by the system. The tags were also to give vehicles' whereabouts to traffic management centers.

Traffic advisories were to include routing around traffic snarls, road conditions and signs, and information from local business yellow pages. Travelers could also pay electronically for toll and parking fees, as well as

services such as lunch at a drive-through restaurant.

Because of the use of beacon transmissions, the vehicles would have needed a cellular telephone. Another need was a route-guidance computer to figure out the best route to a destination and then guide its driver over that route. Planning for the trip could be handled by interactive TV in the home, at the office, and at kiosks located in hotels, bus stations, and other public areas. To warn drivers of an impending collision, radar would be used.

Others in the Hughes team were Delco Electronics, Electronic Data Systems, General Motors, Hickling, JHK & Associ-



example, 25 °C would feel good to most people. Translating this into fuzzy terms, 25 °C would be 100 percent true for an input membership called "comfortable," but 20 °C might be zero percent true, as might 30 °C.

Membership categories, says Valentine,

could include "icy cold," "cold," "cool," "comfortable," "warm," and "hot." The ambient and user setpoint memberships are shown graphically on the opposite page. Inputs like outside temperature, humidity, and solar radiation could be added for a high-performance system.

This "fuzzifying" of the input signals is the first of the three parts of a fuzzy design. The second is to assign membership functions to the output control signals [figure at left, which shows only the heater side]. These functions are classified as singletons, which give only one value per membership.

Thirdly, the so-called min-max inference method is used to establish rules with the help of a matrix [left] representing the input and output memberships and rules. The matrix size is determined by the input membership quantity (5 for the user setpoint, 6 for the ambient temperature), yielding 30 possible rules. Then the designer selects which output membership functions should occur for each input membership function.

Valentine also tells how fuzzy logic relates to the error calculation algorithm for cruise control. Here, he notes, simple linguistics like "if speed difference is negative and small, then increase throttle slightly" are used. The throttle position update rate can also be determined by a fuzzy program that "looks for the driver's cruise performance request (slow, medium, or fast reaction), the application type (small, medium, or large engine size), and other cruise system factory preset parameters."

Other program design requirements would include: verifying the input signals were within expected limits; and testing vehicle speed to resume setpoint speed. This last would prevent, for example, too fast an acceleration to setpoint speed if the cruise resume switch should be engaged when the vehicle enters heavy traffic ("if resume and large speed error, then increase throttle slightly"). —R.K.J.

ates, the Michigan and Minnesota DOTs, Sprint, and the University of Minnesota.

Flexibility marked the outlook of the Westinghouse Electric team, which linked eight physical systems by a flexible communications infrastructure. Team members included Bell Atlantic Mobile Systems, Calspan, Florida DOT, Frederic R. Harris, Harris Corp., Maryland DOT, University of Florida, and Washington State University.

As for the last two approaches, "federal" architecture was used by the Loral Federal Systems team. In other words, a set of independently deployable subsystems was being designed to work together cooperatively using open interfaces. Other team

members were Ameritech, Louis Berger & Associates, New Jersey Highway Authority, Oakland County Michigan Road Commission, Siemens, and the University of Michigan.

Layering distinguished the Rockwell International team's architecture. The team defined the interfaces to be developed among three complex entities, each represented as a layer. The institutional layer was to define requirements and constraints. The transportation layer was to propose solutions to those requirements and constraints. And the communications layer was to provide the means to transmit control instructions and exchange data among the

layers. The other partners were Apogee Research, California PATH, California DOT, George Mason University, GTE Laboratories, Honeywell, Iowa State University, New York State and Texas DOTs, and the Texas Transportation Institute.

Phase I of the ITS program ended in late January, when DOT, after reviewing and evaluating all the approaches, selected the teams led by Loral Federal Systems and Rockwell International to continue into Phase II. They were awarded contracts for \$3.7 million and \$4.3 million, respectively, to perform work that will lead to a consensus national architecture by the summer of 1996. Most of the ele-

ments of a national architecture are expected to be in place by late this year or early 1996.

Engine immobilizers

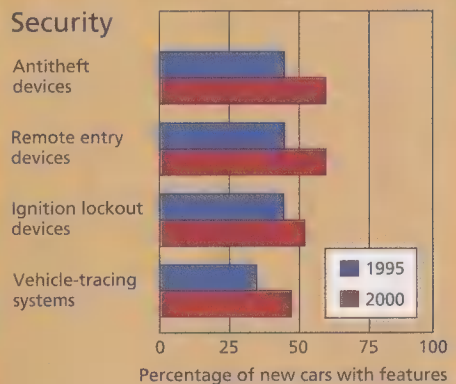
WITH CAR THEFT a plague worldwide, the pressure is on to devise deterrents that thieves will not readily circumvent. Older systems are no longer effective. In Europe, for example, the use of an in-line interrupt to disable a vehicle is being phased out since the system is too easy to hot-wire. Within the year German regulations will call for vehicle disabling that must be done electronically through the engine control module, reported Keith W. Banks, vice president of sales and marketing, TRW Transportation Electronics Division, Farmington Hills, Mich. Speaking at the Convergence meeting in October, Banks said that thieves who intercept signals from the RF transmitter to the receiver in a car, record them, and play them back later in order to steal the vehicle, can be thwarted if the system uses rolling code. This, Banks explained, changes the code each time the system is used, thereby making copied code useless.

A rolling code is usually produced by a linear feedback shift register (LFSR), according to a report at the same meeting by Alan M. Finn, Robert E. LaBarre, and Roger D. Carroll, for United Technologies Research Center, East Hartford, Conn. They described the LFSR as a counter whose operation is governed by Galois field theory mathematics and by exclusive-OR (XOR) gates. But in the LFSR, unlike an ordinary counter, the order of the numbers appears to be scrambled and hence unpredictable.

The LFSR has three parts: a shift register containing a sequence of bits (the message), a feedback register containing another bit sequence (the key), and a rule for combining the shifted bit sequence with the feedback key. In a typical LFSR, given an n -bit input message in the shift register and an n -bit feedback key at the inputs to the XOR gates, the LFSR shifts the message a single bit to the right, bringing in a 0 from the left.

If the shifted-out bit was a 1, the feedback key sends the shifted message to the XOR gates. If the shifted-out bit was not a 1, nothing happens. To ensure the message is completely mixed, these steps are repeated n times. The encrypted message is the data left in the shift register. It is this output that is retained as the next input message.

However, current vehicle immobilizers based on a rolling-code LFSR have a drawback: the LFSR output message can easily be determined by Galois field theory. Cryptographic-directed scanning, the group not-



Source: Siemens Automotive Corp. and Ward's Auto World

ed, can be used to eliminate likely guesses at computer speed, so that only those remaining are tried on the car. A better approach is to use two LFSRs, with one acting as the clocking mechanism to control the other. The result is a mathematical analysis that is orders of magnitude more difficult than the simple analysis for a single LFSR.

Another type of electronic immobilizer system was introduced at the Convergence congress is an advanced version by Siemens Automotive LP, Auburn Hills, Mich. Launched in Europe last year, the system is now being marketed in North America. It uses a low-frequency transponder, as well as battery power, to communicate with an on-board receiver when the motorist approaches the vehicle.

The system does more than just activate the engine controller. Because it is combined in a single unit with the RF or infrared actuators, it can unlock the doors and initiate any other desired electronic functions, such as adjusting the driver's seat, the outside mirrors, and car cabin temperature to preset positions. The smart

card version of the system requires no ignition key. A multistage switch is activated as soon as the motorist is seated in the vehicle. Since the driver must be carrying the smart card, the engine cannot be turned on when the car is unattended.

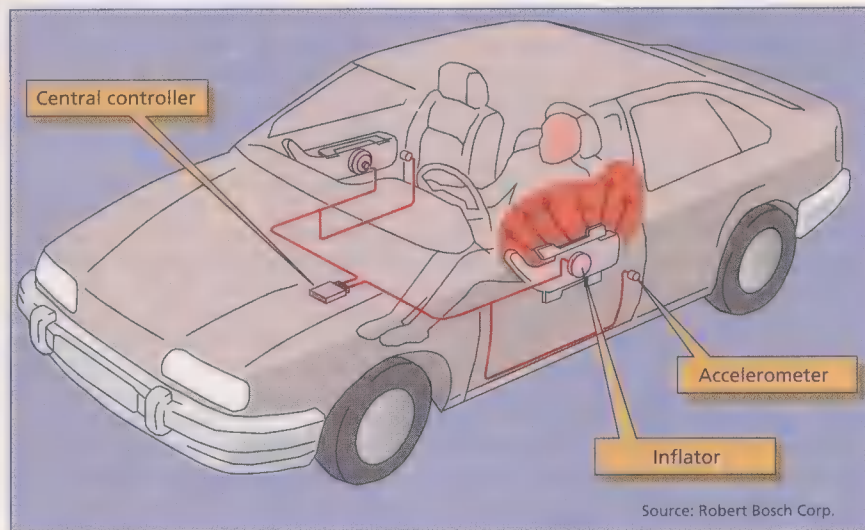
When the vehicle is taken to a service center for maintenance or repair, the card can also be used to retrieve diagnostic data and other operating information from the vehicle's engine control unit for later reference. The basic systems cost about \$100 to \$150.

But if a car has been stolen, despite the antitheft devices installed in it, the next best thing is to locate it quickly. One system gaining popularity for doing that is the Lojack system, which makes use of a radio broadcast system to help local authorities track a vehicle.

For \$600 or so, a car dealer installs a radio transceiver somewhere in the car. At the same time, the police department is notified, and the vehicle identification number already in its computers is paired with a reply code of five letters and numbers specific to that vehicle. The police cruisers also need special equipment.

When notified of the theft of the vehicle, police officers enter its ID code into their computer. A broadcast system is alerted by this event to signal the stolen car's Lojack unit to turn on. Police cruisers within about 52 km² of the stolen vehicle can pick up its Lojack signal on their antenna for identification by the on-board tracking computer. The computer flashes a reply code on the cruiser's display screen, an electronic compass points to the direction to follow, while a signal-strength meter indicates the distance from the cruiser to the stolen car.

Lojack is said to allow the recovery of 95 percent of stolen cars. But it only works,



Source: Robert Bosch Corp.

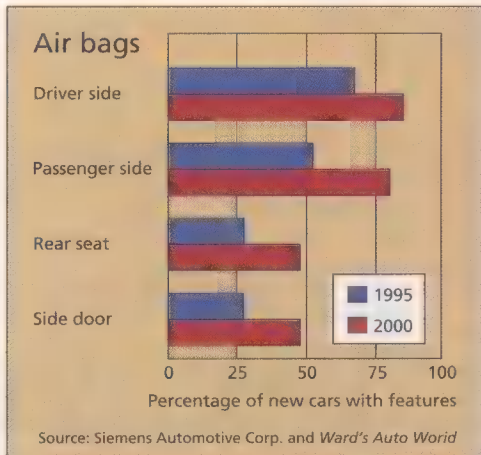
▲ Side impacts affect victims sooner than frontal collisions. In the Bosch Automotive Group's system, side-mounted accelerometers trigger side air bags via a central sensing unit in 5 ms.

of course, in places where the manufacturer has donated the hardware for the system to state and local police. According to the *New York Times*, Nov. 6, 1994, Lojack is available in the Miami, Tampa, and Orlando areas of Florida; Georgia; Illinois; Massachusetts; Michigan; New Jersey; New York City and southern New York State; Rhode Island; and Virginia. Los Angeles County, Washington, D.C., and Connecticut will be the next areas to be equipped with Lojack systems. Competing systems are available, according to the *New York Times*, from Code-Alarm, Chapman, and Teletrac, with prices ranging from \$300 to \$1500 and with monthly monitoring charges from \$8 to \$15.

Automated collision alert

Locating a stolen vehicle quickly can mean the thieves are caught and insurance dollars saved, but there is a more pressing need for finding cars fast: to get medical personnel to an accident as soon as possible. Such a system could be available in five years, according to scientists Raymond L. Yuan, Robb W. Newman, Stanley E. Young, and Eric D. Holm from the Johns Hopkins University Applied Physics Laboratory, Baltimore, Md. At the Convergence meeting, the group described an automated collision notification system that has been identified as a critical component of the Emergency Notification and Personal Security user service (defined in the National Program Plan for the ITS).

In-vehicle equipment for this notification system, the Johns Hopkins researchers said, basically senses a crash, locates its site, and notifies a medical service. Crash sensing involves measuring changes in the vehicle's static or dynamic conditions and determining if they are due to a crash. Locating



the car crash involves estimating the vehicle's position after the crash. Finally, there must be equipment to communicate the crash location to the local emergency medical service (EMS) dispatcher.

To be most effective, crash sensors, relying on vehicle deceleration and chassis deformation, should be able to distinguish between an injury-inducing crash and normal vehicle operations. Some of the technology to make that distinction is already being used in air bag systems. In other words, accelerometers or electromechanical switches that take less than 200 ms to detect large changes in a car's speed could also be applied to a notification system, according to the Johns Hopkins group. Chassis deformation detectors could be strain gauges or accelerometers placed on various locations in the vehicle.

In locating the crash site, conceivably such systems as Lojack could be used, but these systems are not available everywhere and the direction-finding equipment is restricted to police cruisers. Other technologies that could estimate where a crash vehicle has come to rest are listed in the table on p. 41, which is based on a table from the group's Convergence congress paper.

Among the technologies that could help in sending the news of the crash from the vehicle to a local EMS dispatcher are those that use satellites in geosynchronous or low earth-orbit or that employ terrestrial communication systems. All these systems have earth hubs or gateway stations that could route emergency messages over the public switched telephone network (the ground stations would have to use the crash location data to identify which EMS dispatcher to alert).

A possible low-cost (under

\$500) notification system was identified by the Johns Hopkins group. It uses a three-axis accelerometer integrated with an 8-bit microcontroller to sense the crash, obtain such data as change in velocity, direction of impact, and indication of rollover, and then assemble the notification message. A low-earth-orbit satellite would transmit the message and locate the crash.

Better air bag systems

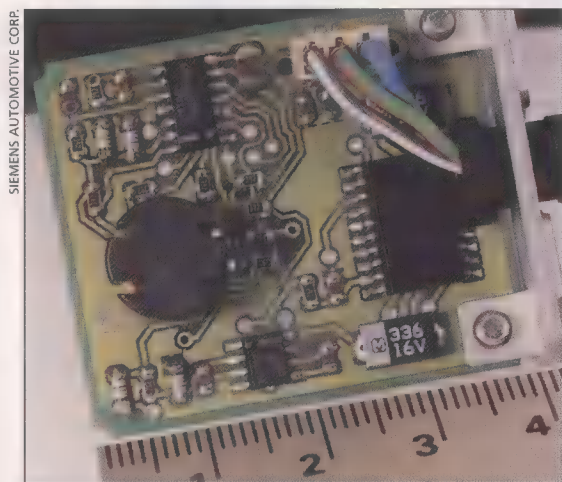
Because air bags are a major means of protecting passengers in a crash, two recent trends concerning the electronics in these systems are worth noting. One is a shift toward single-point electronic sensing (and away from the conventional multiple electromechanical sensors) to reduce cost and complexity. The second is the availability of side-impact air bags to supplement bag systems that deal with frontal collisions.

Single-point systems are produced by Siemens Automotive. The company bases its system on the use of an electronic acceleration sensor that detects how much a vehicle is accelerating and then generates an electric signal. After amplification and filtering, this signal is fed to a microprocessor that evaluates the acceleration signal in real time. From the pattern of the signal, the electronic control unit determines whether the crash is severe enough to release the air bag(s) and assesses how fast to deploy it. Depending on how serious the crash is, the unit will deploy the air bag(s) in 10–20 ms after impact.

In side-impact collisions, how close occupants are to the vehicle's sides can exacerbate the harm done. Both impact sensing and air bag deployment in side-impact systems must therefore be faster than for frontal collisions. Robert Bosch Corp.'s Automotive Group, Broadview, Ill., has developed a sensor for side air bags that triggers in under 5 ms. Bosch reports that with a new gas generator, it is possible for an air bag to deploy just 10–12 ms after being triggered. The company expects the sensor to go into production in 1996.

But monitoring the minimal gap between a vehicle's interior and its occupants, according to Bosch, would require extra, outlying sensors installed near the zone of initial impact. They would have to be mounted in the vehicle's periphery (on the B-pillar or cross members under the seat). The air bags themselves could be stowed in seats, backrests, headliners, roof rails, doors, or B-pillars.

Prototype testing at Bosch to detect accelerations from side-impact collisions has shown promising results. Side-mounted accelerometers are located at the car's B-pillars, cross members, or in the doors,



▲ Siemens Automotive's side-impact air-bag electronic control module features a patented absolute-pressure sensor [disc shape at left center of circuit board], which monitors any change in external air pressure inside the door panel.

where they register the impacts of large objects. A distinct increase in acceleration differentiates life-threatening side collisions from simple hammer blows and is picked up by the central evaluation electronics to which the accelerometers are connected. The central unit controls the final decision to inflate the air bags [see figure, p. 46]. To date, this single electronic control unit has reacted only to a frontal collision, by triggering the driver and passenger air bags.

Another side-impact air-bag system—or rather, control module—comes from Siemens Automotive [see photo, p.47]. A patented absolute-pressure sensor measures any change in external air pressure inside the door panel. If a hefty side impact occurs, the pressure sensor measures the blow and processes it and then, if necessary, deploys the side air bag—all in about 5–7 ms.

Bosch has also been working on an advanced side-impact detection system that would refrain from deploying an air bag for an empty passenger seat. It would also enable Bosch to exploit a recent ruling by the National Highway Traffic Safety Administration (NHTSA) affecting light trucks equipped with a passenger-side air bag. These vehicles are now permitted to have a switch mounted on the instrument panel for the driver to turn on and off by hand, to restrain or ready that air bag. Eventually, the traffic safety administration said, the switch may be replaced with an automatic detection system.

Children and air bags are a concern. The traffic safety administration has also ruled that the new rear-facing child safety seats must now have warning labels from the manufacturer, to the effect that deployment of passenger-side air bags pose risks to children seated there and that the seats should be placed instead in the car's rear seats.

Bosch's solution is a device that detects when the passenger seat is occupied. The sensor uses a capacitive measuring principle (avoiding the need for mass-sensitive sensors). The side air bag will not deploy if the seat is detected as unoccupied, even if the seat contains heavy objects or a rear-facing child safety seat.

Other companies are also developing prototype systems to detect the presence of front-seat passengers or rear-facing child seats. They are using such technologies as CCD cameras and ultrasonic, infrared, capacitive, and phototonic sensors.

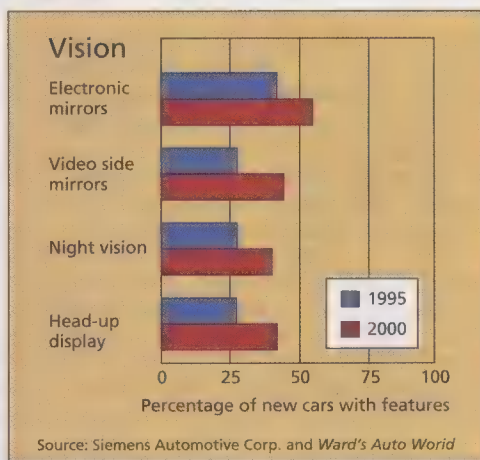
Flat tires flagged

Systems that warn of low tire pressure are on offer by several manufacturers. Epic Technologies Inc., Norwalk, Ohio, for ex-

ample, is marketing a system that consists of four small wheel modules, one fastened to each wheel, and a radio receiver mounted in the vehicle under the dashboard.

Each module contains a 6-V lithium battery, a piezoresistive pressure sensor, and a 200-nW, pulse-code-modulated transmitter operating at 355 MHz. The tire pressure for each wheel is displayed on the car's driver information center panel. The center's wheel identification box blinks if the tire is underinflated.

A similar system has been demonstrated by Delco Electronics. It makes use of four small black boxes wire-banded to the wheel rim just inside each tire. Each box



is a battery-powered RF transmitter that sends signals to the remote keyless entry system. When the vehicle is first started, a display on the instrument panel indicates the current condition of each tire. Pressure is constantly monitored and, when it gets too low, a warning light on the instrument panel goes on.

The Delco system is available on the Chevrolet Corvette, provided the car is fitted with Goodyear GS-C EMT (extended mobility tires). These tires can run up to 320 km at 88 km/h at zero inflation pressure. Since they do not appear to be flat when they are without air, a low-tire-pressure warning system is needed to alert the driver to a loss of air. The handling, ride, and lateral stability of the run-flat tires are impressive even at zero inflation.

Driving in the dark

Night is the *bête noire* of all motorists, especially as they get on in years. But infrared equipment could help prevent accidents during the hours of darkness. The techniques are adapted from night vision technology used in Desert Storm.

Infrared cameras on the roofs of police cruisers were key in tests run in conjunction with law enforcement agencies and described at the October Convergence

congress. Three companies joined forces in the effort: Hughes Aircraft, Texas Instruments, and Delco Electronics. The cameras panned across the surrounding scene and displayed the images on both active-matrix LCD panels and head-up displays inside the cruiser cabs.

The thermal imaging techniques used by the system made warm objects, like cars, people, and animals, stand out. The camera operates at wavelengths of 8–12 μm . The scene radiation is modulated by a chopper and focused by an optical imager on a two-dimensional array of infrared sensors, which convert the radiation into electric signals. The silicon IC, on which the sensors sit, amplifies the detected signals, multiplexes them, and feeds them into a single analog sampled-data signal. The signal then is digitized, an action that normalizes the responses of the individual elements, and a standard output is produced that interfaces to video monitors and recorders.

So far as the police are concerned, the system could help their work at night in chasing fleeing suspects, identifying recently driven vehicles, and previewing the road and terrain ahead. Other gains could be an efficient search and rescue, greater safety and security for the officers, and the ability to deal with a covert operation in total darkness.

Already prototypes of vehicles that include the night vision system have been developed to assess the system's value to the buyer of a passenger car. To be practical, though, costs must be brought down considerably, not only for passenger cars but for police vehicles as well. Commercial and military systems presently cost as much as \$100 000 per unit.

To probe further

The *Proceedings* of the 1994 International Congress on Transportation Electronics includes the papers from the October Convergence '94 meeting held in Dearborn, Mich. Copies are available for US \$88 from the IEEE (IEEE Catalog No. 94CH35729; 800-678-IEEE).

Another good source for material described in this report is the *Automotive Electronics Handbook* (McGraw-Hill, New York, 1995, \$89.50). Ronald K. Jurgen, its editor-in-chief is the author of this article. To order, call 800-822-8158.

More information on the Intelligent Transportation System architecture development program is available in a summary report of Phase I, issued November 1994. For a copy, contact ITS America, 400 Virginia Ave., S.W., Suite 800, Washington, DC 20024-2730; 202-484-4847; fax, 202-484-3483. A panel session entitled "Progress in Developing ITS Architecture," will take place on March 16 during ITS America's annual meeting, Washington, D.C., March 15–17.

A few germanium atoms in just the right places
lift silicon ICs to III-V performance heights
without sending prices through the roof

RE-ENGINEERING SILICON: Si-Ge heterojunction bipolar technology

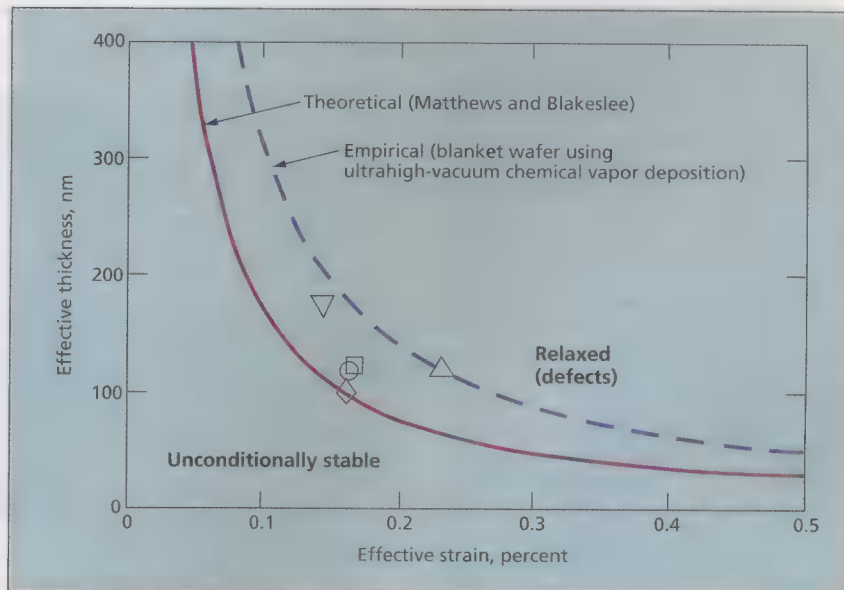
THE STRONG POINTS of compound and single-element semiconductors are united in a new type of transistor. A chip designer's dream, the device is the offshoot of unlikely partners: the bandgap engineering that enhances III-V compound semiconductors, and the manufacturing economies of silicon. Yet the development also harks back to those long-distant days when germanium was king—a reign that lasted from the first working transistors until its dethronement by the less costly silicon in the 1960s.

Within the past decade, techniques for growing crystalline materials have advanced to the point where germanium can be selectively introduced into silicon. When germanium is used to dope the base region of a silicon bipolar transistor, which in other respects is quite conventional, the result is a silicon-germanium heterojunction bipolar transistor. Further, the new device's properties may be tailored tightly to the needs of a desired application, because the profile and concentration of the germanium can be controlled with great accuracy. Hence the IC designer's new-found ability to devise high-speed, low-cost chips.

The evolution of SiGe technology has been rapid. It has gone from a mere laboratory curiosity less than seven years ago to a commercial reality today. Currently, aggressively designed SiGe transistors have cutoff frequencies in excess of 100 GHz—an achievement that puts them in the same league with III-V semiconductor devices and ahead of the best silicon transistors by a factor of more than two.

JOHN D. CRESSLER
Auburn University

In fact, the technology may even help shape the development of the information superhighway. For



▲ The stability of a silicon-germanium alloy on a silicon substrate depends both on the film's thickness and on the amount of strain created by adding germanium. The greater the strain, the thinner the film must be to remain stable. A film whose thickness and strain are below the theoretical Matthews-Blakeslee stability limit [solid curve] are thermodynamically stable. Those above it are metastable, and will relax to the smaller silicon lattice constant under high-temperature processing, generating defects. An empirical stability curve [dashed line] was derived for SiGe films deposited by the ultrahigh vacuum/chemical vapor deposition technique on bare silicon wafers that were subsequently annealed. Data points ■■ from actual SiGe profiles of ■ variety of experimental SiGe heterostructure bipolar transistors (HBTs).

one thing, very speedy converters can be built with SiGe, as record-breaking medium-scale ICs show. An example is a 12-bit digital-to-analog converter that processes data at 1.0 gigasample per second. Recent work also suggests SiGe could offer low-cost, high-speed radio-frequency and microwave ICs to the booming market in wireless communications.

Coming to the aid of silicon

What led to this esoteric development? Silicon is by far the most widely used semiconductor material and is likely to remain so for the foreseeable future. The element is abun-

Defining terms

Chemical vapor deposition (CVD): the deposition of a chemical species from a gaseous mixture (for example, silicon from silane = SiH_4).

Cutoff frequency (f_T): frequency at which the transistor small-signal current gain is unity.

Early voltage (V_A): a measure of the change in base charge (and hence in collector current) with respect to changes in the base-collector bias.

Heterojunction: a pn junction formed between two semiconductors of differing bandgap (for example, n-type silicon and p-type SiGe).

Maximum oscillation frequency (f_{max}): frequency at which the transistor small-signal power gain is unity.

Mole fraction: the ratio of the number of moles of a substance in a mixture or solution to the total number of moles of all the components.

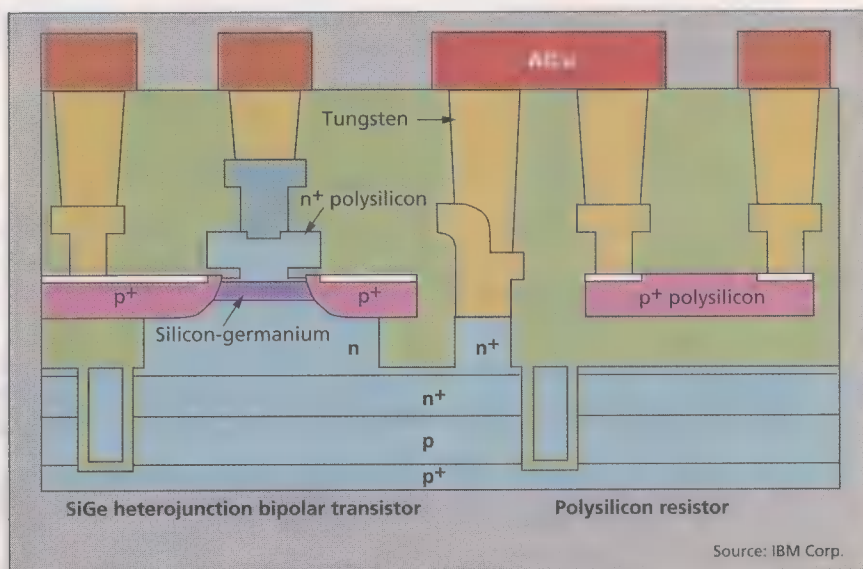
Ring oscillator: a series connection of logic gates with an odd number of signal transitions; it can be used to measure the average switching delay of the logic gate.

Strained-layer epitaxy: growth of a crystal of one lattice constant on a second crystal of differing lattice constant in such a manner that the two materials adopt a common lattice constant while maintaining perfect crystallinity across the growth interface. To accomplish this, the composite film undergoes strain.

dant, nontoxic, strong, and an excellent conductor of heat. It can be grown into ultra-pure, very large-diameter crystals and readily forms a stable insulating oxide of high quality. Properties of this kind make silicon a natural for IC manufacture, and in fact, over the past 30 years or so, the performance of silicon ICs and the density of devices per unit area have soared, even as the cost per function has plunged. These exponential trends have no precedent in economic history and are in large measure responsible for the Information Age.

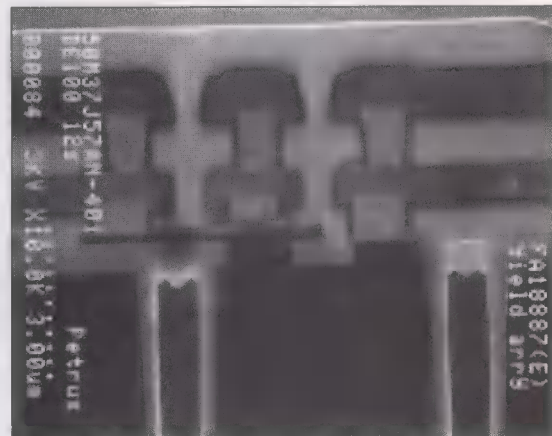
Yet from a transistor designer's perspective, silicon is hardly the perfect semiconductor. Compared with some of the others, it is quite poor in terms of how fast charge carriers can move through the crystal lattice. This sluggishness limits the speed at which silicon devices can operate. Nor can the element easily be made to emit or absorb light in useful quantities.

Far higher charge-carrier mobilities and saturation velocities, as well as a great capacity for producing light, are to be found in III-V compound semiconduc-



▲ In this advanced self-aligned SiGe IC, each heterojunction transistor is isolated by 1.0- μm -wide trenches etched 4.0–5.0 μm into the silicon substrate and refilled with a composite of polysilicon and oxide. Isolating the wafer surface is an oxide deposited in shallow trenches etched 0.5 μm deep and then smoothed by chemical-mechanical polishing. Heavily doped n^+ and p^+ polysilicon layers form the contacts to the emitter and base regions, respectively. A tungsten layer interconnects devices locally, and planarized aluminum-copper is used for circuit wiring.

This scanning electron micrograph of the cross section of a state-of-the-art SiGe HBT delineates the transistor's various layers. The SiGe layer is impossible to distinguish from the silicon substrate.



tor materials, such as gallium arsenide, aluminum gallium arsenide, and indium phosphide. Almost endless variations on their chemical composition are also possible. Adjustments of the amount of aluminum in AlGaAs, for instance, will tune the material's energy bandgap to the transistor designer's needs. Bandgap engineering, in fact, is a powerful tool for creating faster transistors, realizing a host of novel electronic devices, and achieving eminently practical goals such as designing a light-emitting or a laser diode to emit light at a specific wavelength [see "Quantum-tailored solid-state devices," by T.J. Drummond, P.L. Gourley, and T.E. Zipperian, *IEEE Spectrum*, June 1988, pp. 33–37].

So why is silicon still dominant? The answer is economics. ICs are simply much more difficult and very much more expensive to fabricate from III-V compounds. High-quality oxides are scarce in the III-V world, impeding device integration; high-purity, large-diameter crystals are difficult to grow; and chip yields are far lower because there are many more defects to the cubic centimeter.

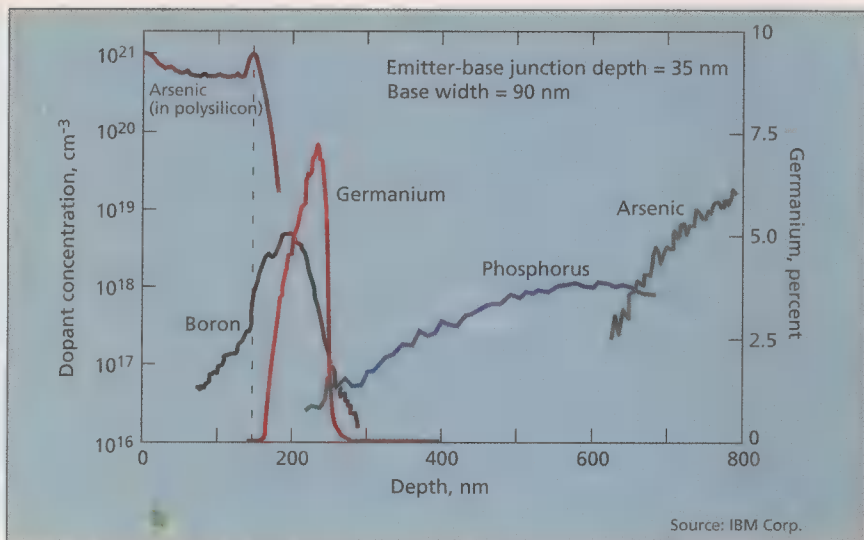
The dream, then, of transistor designers

has been to practice bandgap engineering in silicon. The SiGe heterojunction bipolar transistor (HBT) is the first practical bandgap-engineered silicon device.

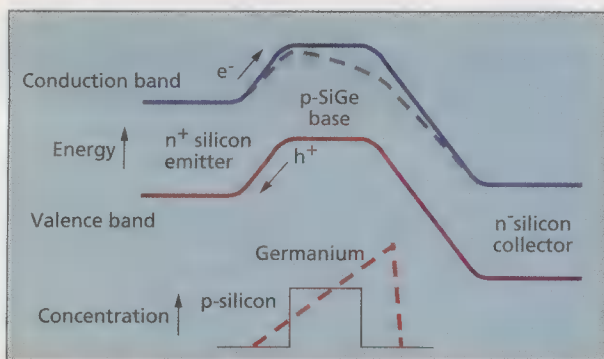
Early showstoppers

Silicon and germanium, being chemically compatible elements, can be intermixed to form a stable alloy ($\text{Si}_x\text{Ge}_{1-x}$, where x represents the mole fraction, and is usually written SiGe for simplicity). But the lattice constant of silicon is about 4 percent smaller than for germanium, leading to a number of practical difficulties in the use of SiGe alloys in semiconductor electronics. One immediate concern is the effect of strained-layer epitaxy.

When bandgap engineering is used to construct a transistor, a perfect crystalline structure is essential, since any defects generated can devastate circuit yields. But the growth of perfect epitaxial films from alloys



▲ The impurity doping profile as a function of depth for an advanced SiGe HBT is obtained from secondary ion mass spectroscopy. The vertical dashed line denotes the silicon surface. Arsenic from a polysilicon diffusion source forms the n^+ emitter, boron the p^+ base, and phosphorus the n^- collector. Germanium is co-deposited with the boron-doped base to produce a p -type SiGe base, and is compositionally graded from the emitter to the collector to introduce a drift field for minority carriers (electrons). The width of the base is approximately 60 nm, and the transistor has a measured peak cutoff frequency of 60 GHz.



▲ Comparison of energy band diagrams of a SiGe HBT and a silicon bipolar junction transistor elucidates differences in their properties. Both transistors are biased identically in forward-active mode. The potential barrier to electron injection from emitter to base is lower in the SiGe than in the silicon device since there is a measurable amount of the smaller-bandgap germanium at the emitter-base heterojunction. This leads to an (exponentially) enhanced current gain for a fixed emitter-base bias. The grading of the germanium across the base introduces a position-dependent conduction band edge. The resulting drift-field aids minority carrier (electron) transport from emitter to collector, increasing the cutoff frequency.

such as SiGe is hampered by their inherent lattice mismatch. While being grown on a silicon substrate, a SiGe film can remain a perfect crystal only by adopting the smaller lattice constant of the host material. This accommodation, known as strained-layer epitaxy, induces compressive strain in the overlying film.

As is well known, strained-layer epitaxy is thermodynamically stable only under a narrow range of conditions dependent on the film's effective strain (percent germanium) and thickness. The critical thickness below which the grown film is unconditionally stable depends reciprocally

transforming the perfectly crystalline SiGe strained layer into a useless amalgam just like a shattered windshield. This no-man's land of strained-layer epitaxy is obviously to be avoided.

Growing SiGe films

To grapple with the difficulties of growing SiGe alloys, molecular beam epitaxy was used alone at first to produce thin, device-quality films. Pioneering studies in the mid-'80s at AT&T Bell Laboratories, Murray Hill, N.J., the IBM Thomas J. Watson Research Center, Yorktown Heights, N.Y., and the Daimler-Benz Research Lab-

oratories, Ulm, Germany, among others, used molecular beam epitaxy to show that SiGe alloys could be bandgap-engineered controllably and successfully used to realize a host of novel electronic and photonic devices. The door to bandgap-engineering in silicon had begun to open.

The issue quickly became how to transfer SiGe technology from the simple device demonstrations in the research laboratory to the practical manufacture of high-volume, low-cost SiGe ICs—a task for which molecular beam epitaxy by itself is unsuited. The kind of SiGe transistors that can be built with the technique is limited to mesa devices (so named because the devices are isolated from one another by etching back deposited layers to form a mesa, rather than by using a conventional field oxide). Although mesa-type devices are useful for studies of transistor physics, they cannot easily be integrated into circuits.

However, by 1986 a key step had been taken toward commercializing SiGe technology—the development of ultrahigh-vacuum chemical-vapor deposition by Bernard S. Meyerson and his co-workers at IBM's Yorktown Heights research facility. They took the ultrahigh vacuum (UHV) of molecular beam epitaxy tools and a conventional chemical-vapor deposition (CVD) process and combined them in a technique that exploits the unique role of hydrogen in regulating the chemistry at the silicon and SiGe growth interface. Thin strained layers of the alloy are deposited on silicon wafers by a UHV/CVD batch tool with the doping and thickness control needed for manufacturing. (The wafers are 200 mm in diameter and have previously been patterned with implants and isolation.) As the tool can process multiple wafers simultaneously, throughput is high and cost is low.

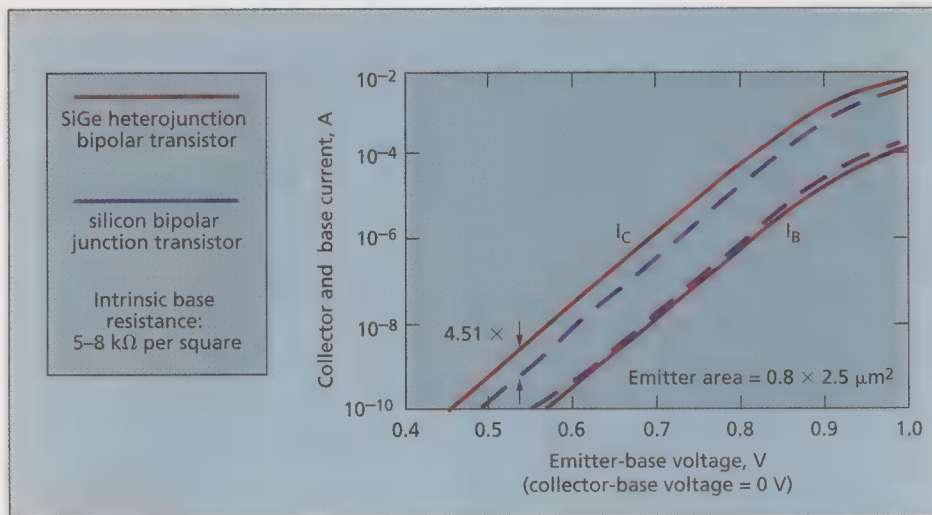
What SiGe buys you

From a device designer's viewpoint, it is distinctly beneficial that the energy bandgap of SiGe alloys is smaller than it is for silicon, lying as it does between silicon's 1.12 eV and germanium's 0.66 eV. The bandgap is further diminished by the compressive strain in the alloy layer (the bandgap shrinks faster with increasing germanium content than might otherwise be expected).

In strained SiGe grown on a silicon substrate, most of the bandgap reduction is due to a valence band offset (about 75 meV for each 10 percent of germanium). The conduction and valence band edges of the strained layers of SiGe lie within the band edges of the underlying silicon, a circumstance that favors the use of bandgap engineering to build fast transistors.

By III-V semiconductor standards, the band offsets in SiGe are not large. Even so,

► Measurements of identically fabricated SiGe HBTs and silicon junction transistors allow unambiguous comparisons. In the first set of curves, the smaller base bandgap of the SiGe HBT enhances the collector current for a given bias, yielding a larger current gain. The drift field induced by the germanium grading reduces the base transit time and so improves frequency response [next set of curves]. A substantial increase in peak cutoff frequency from 30 GHz to 113 GHz is observed with the graded SiGe base. The last set of curves compares the unloaded gate delays of a SiGe HBT ECL ring oscillator with those of an oscillator made with silicon junction transistors. The improved frequency response of the SiGe HBT translates into improved large-signal switching performance.



a big advantage can be gained by the controlled grading of germanium with growth techniques such as UHV/CVD. In practical SiGe devices, grading from 0 to 15 percent germanium may occur over distances as short as 50-60 nm, yielding induced electric fields of 15-20 kV/cm. Such very large fields soon accelerate charge carriers to saturation velocity, about 1×10^7 cm/s, promising very fast devices.

One final benefit of employing SiGe strained layers is that the carrier mobility is enhanced by the presence of strain in the alloy. This good fortune translates directly into lower-resistance layers for majority carriers and reduced transit times for minority carriers—both beneficial for realizing fast transistors.

From materials to devices

The base region of a bipolar transistor is critical to device speed, since this parameter is fundamentally limited by the time the carriers take to cross the base (base transit time). In effect, the base must be designed to be as thin as possible. Moreover, the useful collector current of a transistor is determined by the bandgap and doping profile of the base region (p-type for an n-p-n device). Since the dc and ac properties of the bipolar transistor can be strongly influenced by manipulating the base, the region is an obvious candidate for bandgap engineering using strained layers of SiGe. It is, in fact, a new and powerful lever for the silicon device designer to use in device optimization for specific applications.

To yield a superior transistor, the base region must be thin to remain stable, must have a smaller bandgap than silicon, and must be capable of forming p-type SiGe (p-SiGe). The last of these requirements entails controllable doping with boron at high dynamic range.

This, then, is the basic idea behind the SiGe heterojunction bipolar transistor

(HBT). Using an epitaxial growth technique such as UHV/CVD, germanium is selectively introduced into the base region of a conventional silicon bipolar junction transistor. The p-SiGe base thus creates an emitter-base heterojunction (n⁺-Si/p-SiGe) as well as a base-collector heterojunction (p-SiGe/n-Si).

Advanced self-aligned SiGe HBTs are built at IBM's advanced microelectronics production facility in East Fishkill, N.Y. Films of the alloy are deposited by means of UHV/CVD on a 200-mm wafer [see cross section, p. 50]. Apart from this step, the device is essentially identical to a conventional silicon bipolar junction transistor and is built with processing equipment common to any advanced silicon fabrication facility.

The physics of the novel HBT is largely determined by the specifics of the doping profile. When secondary ion mass spectroscopy is used to measure dopant concentrations in one of the transistors, the device is shown to have a peak germanium content of only about 7.5 percent, be only 70 nm wide, and as a consequence be unconditionally stable as grown [see profile, at top of p. 51].

How it all works

THE SMALLER BASE BANDGAP of the SiGe HBT is exploited in three ways, which can best be understood by considering an energy band diagram of the transistor [see lower diagram, p. 51]. First, note the reduction in base bandgap at the emitter-base junction. This base bandgap reduction exponentially increases the collector current for a given bias voltage, so that there is a large increase in current gain compared with a silicon bipolar transistor. What has happened is that germanium (with its smaller bandgap) has been added to the emitter-base junction. In effect, for a given bias, more electrons are

injected from emitter to base, where they contribute to the collector current.

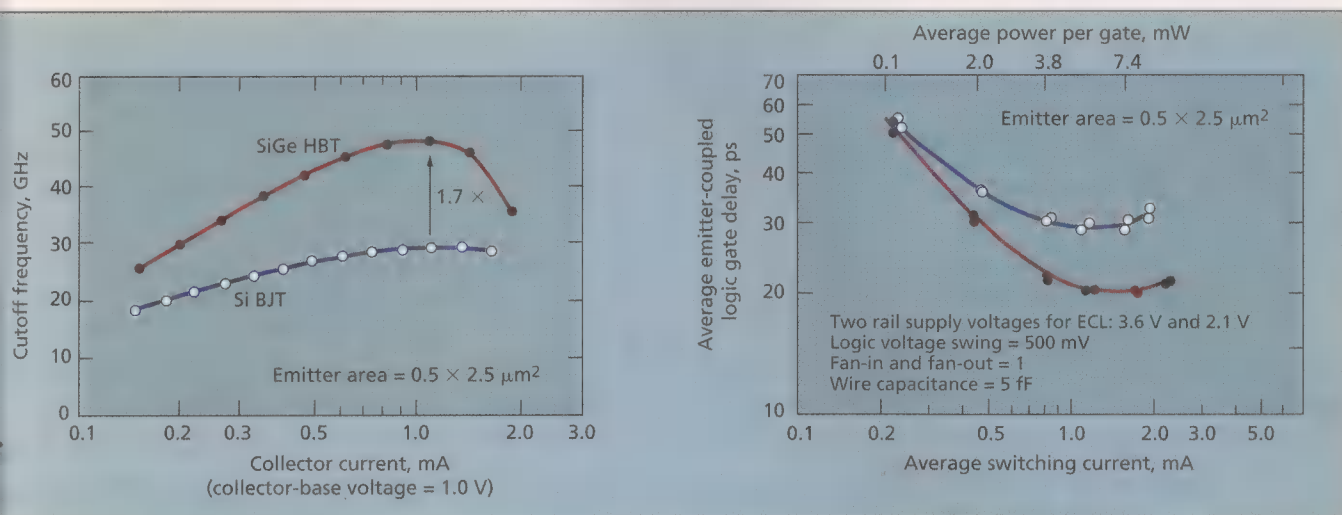
Secondly, if the germanium content is graded across the base region of the transistor, as is easy to do with the UHV/CVD technique, the conduction band edge becomes dependent on position, inducing an electric field in the device. This field accelerates injected minority electrons as they traverse the base. The base transit time of the SiGe transistor is thereby shortened, and its frequency response much improved [center set of curves, above].

Recent studies at the Daimler-Benz Research Laboratories as well as at IBM's Yorktown Heights facility demonstrate that, as noted earlier, the upper bound on cutoff frequency in aggressively designed SiGe HBTs is well above 100 GHz, more than a factor of two higher than the best achieved in silicon, and comparable to many GaAs-based technologies. Of note, too, is the fact that the IBM group achieved a peak cutoff frequency of 113 GHz in a device that has an intrinsic base sheet resistance of only 7 kΩ per square.

Finally, SiGe improves the output resistance of the transistor, a crucial feature in analog design. Of help in this context is the Early voltage, a measure of the ease with which the majority carrier profile in the base is depleted by an applied base-collector bias. For a SiGe HBT with a germanium grading from emitter to collector, the Early voltage increases exponentially with the amount of bandgap grading across the base.

In effect, the position dependence of the bandgap of the graded-base SiGe profile weights the base profile toward the collector region. The base region therefore becomes harder to deplete than for the comparably doped silicon transistor and yields a larger Early voltage.

Now, a transistor with a large Early voltage has a very flat common-emitter output characteristic and hence high output resistance. For the devices depicted in



the curves above, the Early voltage of the SiGe transistor is 53 V, nearly three times the 18 V for the silicon device.

Moreover, cooling enhances all the aforementioned attributes of the SiGe HBT. In striking contrast to the silicon junction device, the current gain, cutoff frequency (f_T), and maximum oscillation frequency (f_{max}) all rise significantly as the temperature drops. This means that the alloy transistor is well suited to operation in a cryogenic environment (say, at the temperature of liquid nitrogen, 77 K), historically the exclusive domain of silicon CMOS and III-V compound semiconductor technologies.

Cryogenic electronics is in growing use for both military and commercial applications such as space-based satellites, high-sensitivity instrumentation, high-transition-temperature superconductors, and future cryogenic computers. The SiGe technology quite naturally and for the first time extends the capability of silicon-based bipolar technology to include this challenging environment.

The games people play

Going beyond its superiority to its silicon counterpart in current gain, cutoff frequency, and Early voltage, the newcomer's biggest asset is perhaps its potential for bandgap engineering. In effect, the device designer is enabled to selectively tune each parameter to a required specification. The only constraint for a practical SiGe transistor design is that the integrated germanium content be low enough to guarantee film stability.

In the silicon junction transistor, the collector current is determined solely by the shape of the base doping profile. But in the SiGe HBT, the collector current, and hence current gain, is effectively decoupled from the base doping profile design. In fact, the current gain of the SiGe HBT can be made large or small, depending on

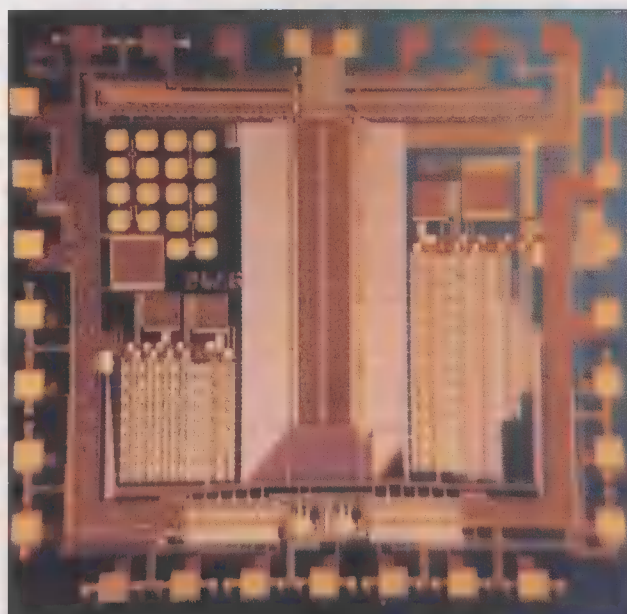
the shape of the germanium profile.

In analog designs, for instance, which frequently require large current gain, more germanium can be placed at the emitter-base junction. Here the optimum germanium profile might be a box rather than a triangle [see diagram, p. 51]. Conversely, current gain in digital designs, which typically do not require it to be high, can be traded for higher base doping and hence lower base resistance. That is, instead of using the germanium to increase the current gain from (say) 100 to 300, the decision might be to triple the base doping. The resulting transistor would still have a current gain of 100, but only one-third the base resistance (current gain is inversely proportional to base doping level).

Because the base transit time limits the frequency response of a bipolar transistor, a high-performance design must have a narrow base. In conventional silicon junction transistors, the region is formed by

implanting boron. With low-energy ion implantation, though, the width of the base can be shrunk only by lowering the boron dose (atoms per square centimeter) and therefore the doping level. At the same time, the resistance of the base depends reciprocally on its doping level, so lowering the doping raises the resistance. In practice, the narrowest base width achievable with ion implantation is about 100 nm for a tolerable base resistance.

For the conventional silicon junction transistor, then, there exists an inevitable design tradeoff between good frequency response and low base resistance. With SiGe, bandgap engineering can be used to relax this tradeoff. The ideal, of course, would be high cutoff frequency and low base resistance (high f_{max}), since the latter is a better indicator of large-signal circuit speed than is the cutoff frequency. Therefore the semiconductor alloy is deposited in very thin, yet heavily doped layers,



STEVE BEST, AUBURN UNIVERSITY

■ This 1-gigasample-per-second, 1-W, 12-bit digital-to-analog converter makes use of 2854 SiGe HBTs and 1465 polysilicon resistors and is wired with three levels of metalization. It is the first commercially available SiGe integrated circuit.

with a graded germanium profile that boosts frequency response. The simultaneous achievement of high cutoff frequency and low base resistance is a key difference between the SiGe HBT and the silicon junction transistor.

An important figure of merit for the performance of high-speed analog applications is the product of a transistor's current gain and Early voltage (BV_A). The analog designer desires the largest possible value of this product, yet in the case of a silicon bipolar transistor, designing for high current gain is diametrically opposed to designing for large Early voltage. To be specific, reducing the base doping level yields a large current gain but makes it easier to deplete the base under base-collector bias (low Early voltage). At the same time, raising the base doping raises the Early voltage, but at the cost of current gain. The challenge, then, of achieving high BV_A in a transistor that still has good frequency response is a formidable one.

The situation is very different with the SiGe HBT. There, the BV_A product depends exponentially on the germanium content at the base-collector junction. A triangular germanium profile, for instance, yields high BV_A and high cutoff frequency.

Some applications

Initially, SiGe HBT technology was investigated with a view to high-speed digital logic applications. Emitter-coupled logic (ECL) circuits, as the *de facto* standard for fast bipolar logic, were fabricated in SiGe and tested to quantify their advantages over comparably designed silicon circuits. One measurement compared unloaded state-of-the-art SiGe ECL circuits with their silicon counterparts. The newcomers were found to switch every 20 picoseconds at 1.2 mA of collector current—a speed advantage of nearly 9 ps [see curves, p. 53 at right].

From the standpoint of a key consideration, power dissipation, this improvement translates into a halving of the power consumed by a switching event, given a constant speed of about one per 30 ps. Larger gains in performance are expected for optimized circuits, whose total base resistance would be reduced by leveraging the higher current gain of the SiGe HBT. In addition, for circuit configurations whose speed is more strongly coupled to frequency response than it is in ECL (examples are nonthreshold logic circuits or active pull-down circuits), SiGe HBTs may well show an even greater advantage.

All the same, the SiGe HBT is perhaps best suited for high-speed analog applications, which can truly use fast transistors with low base resistance, low noise, excellent high frequency response, and large BV_A product. To prove the point, a 12-bit, current-output, digital-to-analog convert-

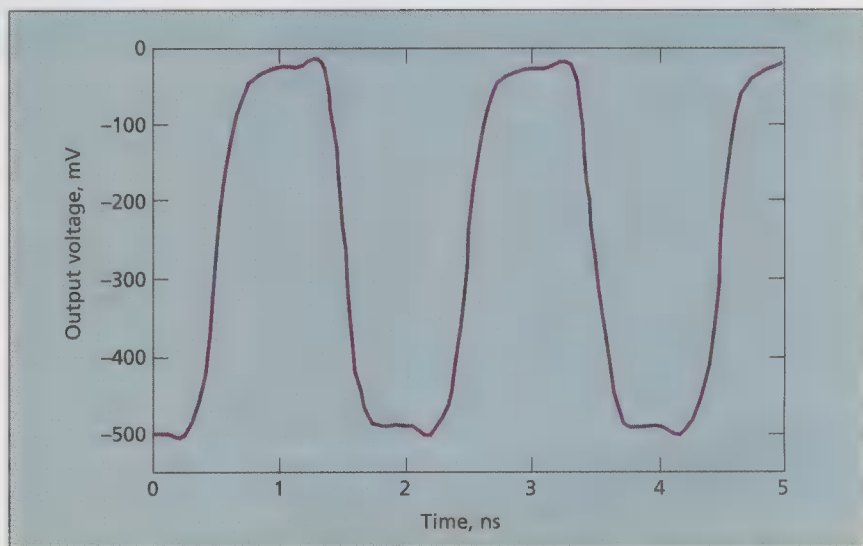
er with an ECL interface has been designed, built, and tested [see photo, p. 53]. It is the first commercially available SiGe IC.

Fabrication employed the UHV/CVD technique in IBM Corp.'s advanced semiconductor production facility in East Fishkill, N.Y., in alliance with Analog Devices Inc., Wilmington, Mass. The converter contains 2854 SiGe HBTs, 1465 polysilicon resistors, a patterned p+ ground plane to speed signal settling, and three levels of metal for interconnections. It is the highest level of integration attained to date by SiGe HBT technology.

It bears repeating that the digital-to-analog converter achieves an update rate of

corner frequencies as low as 300–400 Hz and noise figures of 0.5 dB at 2.0 GHz and 0.9 dB at 10 GHz.

With the growing concern for power management in VLSI systems and portability for wireless communications, SiGe HBT technology has another compelling advantage: the fact that it can be integrated with conventional CMOS silicon circuits to form a biCMOS technology in which the bipolar transistors are SiGe HBTs. Here, the SiGe HBTs can be exploited for critical high-speed analog or digital functions and the silicon CMOS can serve for very high-density memory or compact on-chip signal-processing functions. The ability to



▲ The measured output of the digital-to-analog converter of the prior figure makes full-scale transitions from all 0s to all 1s in 1 ns—performance comparable to the best GaAs versions.

1.0 gigasample per second at less than 1.0 W [see waveform above], a record performance for silicon technology, and comparable to the best GaAs converters.

Preliminary studies indicate that SiGe HBT technology is ideally suited to other historically demanding analog functions. These include low-noise, high-bandwidth amplifiers, mixers, and voltage-controlled oscillators, all key functions for radio-frequency and low-end microwave communication systems.

To date, power-added efficiency, a key figure of merit for high-bandwidth amplifier design, has been measured to be as high as 70 percent in SiGe HBTs, nearly double that of silicon junction transistors and comparable to the figure of merit for GaAs MESFETs. Transistor noise often constrains the design of communication systems. Early measurements of SiGe HBTs indicate that for low-frequency (less than 10 kHz) and high-frequency (2–10 GHz) noise, they are comparable to the best available GaAs devices. Recent reports aver that SiGe technology permits

integrate SiGe HBT with CMOS processes sets the new technology apart from the III-V technologies, which cannot supply the high-quality native oxide essential to implementations in CMOS.

As early as 1992, a fully integrated SiGe biCMOS technology was demonstrated at IBM's Thomas J. Watson Research Center. UHV/CVD served for alloy growth and conventional optical lithography for pattern definition. The result included SiGe HBTs with 0.5- μ m geometry, CMOS FETs with 0.25- μ m geometry, decoupling capacitors, and polysilicon and ion-implanted resistors. In this biCMOS process, the SiGe devices attained a cutoff frequency of 50 GHz, a record maximum oscillation frequency of 60 GHz, and unloaded ECL gate delays as short as 19 ps. The CMOS devices yielded state-of-the-art extrinsic transconductances of 240 mS/mm and 140 mS/mm for the n- and p-type transistors, respectively.

The numerous coming wireless applications could benefit from the economical integration of complex radio circuitry. For

instance, a mixed-signal SiGe BiCMOS technology could be used to build a radio on a chip that would operate at 2.0 GHz and above. Because a silicon substrate (unlike \square GaAs one) is inherently conductive, the high-Q capacitors and inductors required are harder to make. Even so, precision monolithic silicon inductors with Q exceeding 10 have of late been demonstrated, and the prospects for improvement look bright as knowledge of silicon micromachining techniques grows.

Intriguing possibilities

While the HBT is the most mature device yet built with SiGe technology, a number of other potentially useful devices have been shown to work. Films of the alloy have been used to fabricate a variety of SiGe-channel MOSFETs, modulation-doped n- and p-channel high-electron-mobility transistors (HEMTs), pnp HBTs, and resonant tunneling diodes. All promise to far outperform their silicon counterparts. For instance, in p-channel MOS transistors, it has been shown that a channel that is 20 percent germanium improves the low-field hole mobility of a SiGe version by 50 percent over an all-silicon device (both transistors having 0.25- μ m features).

Then, too, the ability to fabricate both p-channel and n-channel HEMTs on the same silicon wafer raises the interesting possibility of a complementary SiGe HEMT technology. A configuration of that kind would be tough to realize with III-V semiconductors.

In the realm of photonics, an assortment of SiGe photodetectors has already been made and operated, including p-i-n, avalanche, and superlattice-based photodiodes. The smaller bandgap of germanium compared to silicon enables these diodes to absorb longer wavelengths, in the range of 1.3 μ m. But III-V compound semiconductors, with their direct bandgap and hence excellent light-handling capability, still enjoy a decided advantage over SiGe, which remains an indirect bandgap material like silicon.

All the same, device designers have long dreamed of silicon-based optoelectronics, which would combine electronics and photonics on the same silicon chip. As envisioned by R. Soref of Rome Laboratories at Hanscom Air Force Base in Massachusetts, such a silicon superchip might have SiGe HBTs, complementary SiGe HEMTs, and conventional CMOS for high-speed analog functions, signal processing, memory, and computation, together with photodiodes for light detection, and silicon-based lasers for light emission.

Because silicon's poor light emission is the biggest obstacle to realizing an optoelectronic superchip of this kind, several research groups are exploring more com-

plicated silicon-based alloys such as silicon-germanium-carbon and silicon-germanium-tin. They hope to discover one that emits light yet stays compatible with conventional silicon fabrication.

As was the case with SiGe HBT technology, SiGe photonic devices cannot hope to compete head-to-head with the GaAs or InP technologies in sheer performance. Rather, they should deliver a better combination of cost and performance. Whatever may be the eventual commercial impact of these more exotic SiGe devices, the alloy suggests many interesting possibilities for the future, a healthy sign in any new technology.

The road ahead

The bottom line is economics. To succeed commercially, SiGe technology has to outperform silicon technology and undersell the III-V technologies. To this end, SiGe ICs must look, taste, feel, and smell like silicon ICs, yet compete in speed with their GaAs cousins.

Offhand, the performance constraint seems manageable, while the eventual cost of SiGe technology will rest on its compatibility with conventional silicon fabrication. It should be noted, however, that state-of-the-art silicon technology (be it CMOS or bipolar) derives a large fraction of its cost from the multilevel metallization and packaging. Thus, no dramatic impact on cost is expected when epitaxially grown SiGe films replace conventional ion implantation for the formation of the transistor base region.

Of course, as new transistor technologies go, SiGe is still an infant. Nevertheless, the signs are encouraging, especially for SiGe grown with UHV/CVD, which has a proven capability on 200-mm wafers in an advanced silicon production environment. The future is bright as the age of silicon-based bandgap-engineered technologies rapidly approaches. Watch out, GaAs, silicon is on the march again! \blacklozenge

To probe further

The electrical and mechanical properties of the SiGe strained-layer epitaxy are described in "Physics and Applications of $\text{Ge}_{1-x}\text{Si}_x$ Strained Layer Heterostructures," by R. People in the *IEEE Journal of Quantum Electronics*, Vol. 22, 1986, p. 1696. A review of the UHV/CVD growth technique and its application to a variety of semiconductor devices can be found in "UHV/CVD growth of Si and SiGe alloys: chemistry, physics and device applications," by B.S. Meyerson, in the 1992 *Proceedings of the IEEE*, Vol. 80, p. 1592.

The basic idea of the heterojunction bipolar transistor can be traced to H. Kroemer's pioneering 1957 paper, "Theory of wide-gap emitter for transistors," *Proceedings of the*

IRE, Vol. 45, p. 273. The first SiGe HBT was reported in "Silicon-germanium base heterojunction bipolar transistors by molecular beam epitaxy," by S. S. Iyer and co-workers (*Technical Digest of the International Electron Device Meeting*, 1987, p. 874). In 1990, the performance potential of SiGe HBT technology was clearly demonstrated for the first time in "75 GHz-f_T SiGe base heterojunction bipolar transistors," by G.L. Patton and others (*IEEE Electron Device Letters*, Vol. 11, p. 171). Later that year, the first fully integrated SiGe HBT circuit technology was reported in "Profile leverage in \square self-aligned epitaxial Si or SiGe base bipolar technology," by J.H. Comfort and his colleagues (*Technical Digest of the 1990 International Electron Device Meeting*, p. 21).

Recent demonstrations of some very aggressive SiGe HBT technologies with cutoff frequencies exceeding 100 GHz can be found in "High-speed SiGe-HBT with very low base sheet resistivity," by E. Kasper and company, in the 1992 *Technical Digest of the International Electron Device Meeting*, p. 79, as well as in "Vertical profile optimization of very high frequency epitaxial Si- and SiGe-base bipolar transistors," by E.F. Crabbé and colleagues, in the 1993 *IEDM Technical Digest*, p. 83.

In the same IEDM volume, on p. 784, D.L. Harame and others outline the circuit technology used to realize the 1.0-gigasample-per-second 12-bit SiGe digital-to-analog converter in "Optimization of SiGe HBT technology for high-speed analog and mixed-signal applications." Chip architecture and design details of the 12-bit SiGe DAC can be found in "Combining silicon and germanium yields 1-GHz, 12-bit DAC," in the Feb. 7, 1994, issue of *Electronic Design*.

The longer-term prospect for SiGe and other silicon-based bandgap-engineered materials for future photonic applications is reviewed in "Silicon-based optoelectronics," by R. A. Soref, in the *Proceedings of the IEEE*, Vol. 81, 1993, p. 1687.

About the author

John D. Cressler is assistant director of the Alabama Microelectronics Science and Technology Center as well as associate professor of electrical engineering at Auburn University in Alabama. His research interests include silicon-germanium device physics and technology, cryogenic electronics, device simulation, and circuit modeling. Prior to joining Auburn University in 1992, he spent over eight years with IBM Corp.'s Thomas J. Watson Research Center, Yorktown Heights, N.Y., where he was \square member of the team that developed IBM's SiGe heterostructure bipolar transistor technology. He is a Senior Member of the IEEE, and in 1994 was awarded the Office of Naval Research Young Investigator Award for his SiGe research program.

WILSON GREATBATCH

Wilson Greatbatch orders a dessert of chocolate cake. When the waitress serves him, he quips: "I wish you'd flipped it over. Then I'd have negative calories!"

The waitress smiles, politely. Engineering is seldom far from Greatbatch's mind. He's a prodigious inventor and tinkerer. Among his projects are a solar-powered canoe, cloned African violets, engines that run on alcohol, and nuclear-powered batteries. In all he has over 140 U.S. and foreign patents, including the one for the implantable pacemaker.

In 1983, the National Society of Professional Engineers chose the pacemaker as one of the 10 greatest engineering contributions to society during the past 50 years. In 1988, Greatbatch was inducted into the National Inventors' Hall of Fame, in Akron, Ohio, for patent No. 3 057 356. He follows in the famous footsteps of Thomas Alva Edison, Alexander Graham Bell, and William George Armstrong.

Yet he is the consummate family man, too, with five children and six grandchildren after over 50 years of marriage. He lives not far from where he was born, in Buffalo, N.Y., and is active in his community. Every fall during the apple-picking season, he hosts a cider-making party. He once owned several Caterpillar bulldozers and occasionally did some earth-moving services for the townspeople. (The town returned the favor a few times by helping him with town zoning on some of his large-scale projects, such as building of factories or digging a 3-hectare lake.)

But first and foremost, Greatbatch is an old-style independent inventor. He has never accepted a government research grant. And whenever a company he helps to create becomes too big, he leaves to pursue his own ideas elsewhere.

Wayward beginning

Intangible things—like music, religion, and radio waves—have fascinated him since his childhood.

An only child of parents who were "relatively poor," he evinced an interest in electricity and electronics early on. "I think it was the mystery of it," he said. "Something was happening that you couldn't see, or feel, or hear. You needed a meter or oscilloscope or at least a neon bulb to detect it and you had to interpret what the reading meant."

In his early teens he built a two-tube short-

The inventor of the implantable cardiac pacemaker—and holder of 140 other patents—lives modestly in upstate New York while he pursues AIDS research

wave receiver and listened to London on a coil he had wound himself. Around 16, he passed the test for an amateur radio license (W8QBD). An active Boy Scout, he joined the Sea Scout Radio Division, which had a station (W8QBU) near the New York State Naval Militia in Buffalo. The station received a Red Cross citation for staying on the air 26 hours straight during the 1938 New England hurricane, to relay messages to other ham stations in Ontario and Ohio.

The station generated social get-togethers, too. A group of girls who called themselves MAD (Men Are Dogs) hung around the Sea Scouts' radio shack and, to the boys' dismay, made curtains for it. "Most of the guys finally married most of the girls, as did I, eventually," Greatbatch said.

In 1939, Greatbatch and many of the other Sea Scouts joined the Naval Reserve unit nearby, all qualifying for a noncommissioned officer's grade because of their radio licenses. They practiced their radio drills while sailing to New York City and Guantanamo, Cuba.

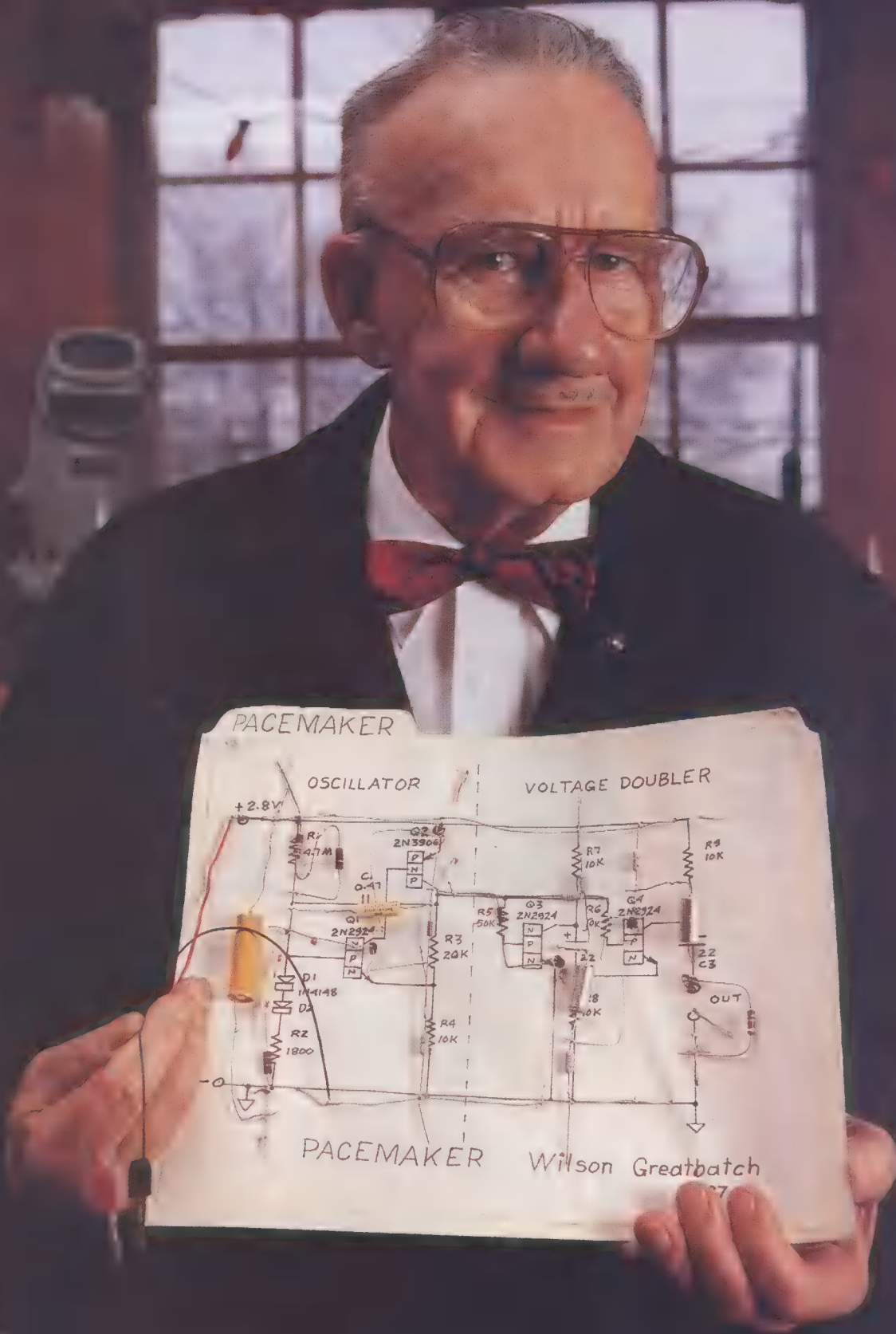
Over the course of World War II, the Sea Scouts trained more than 50 radio operators. Greatbatch served five years. Among his duties were repairing electronics on a destroyer, serving as radioman on convoys to Iceland, teaching radar in Texas, and finally flying in the Pacific as a rear gunner off the USS *Monterrey* aircraft carrier. In six months of combat, a third of the squadron crew was killed.

After the war, Greatbatch returned to Buffalo

► Greatbatch designed pacemaker circuits on manila folders and attached components opposite the sketch. Nowadays he uses such "working pacemakers" for classroom demonstrations. He hooks up a battery at one end, while a transistor radio amplifies the circuit's life-giving rhythm for all to hear.

JOHN A. ADAM
Senior Associate Editor

Wilson Greatbatch



Vital statistics

Name: Wilson Greatbatch
Born: Sept. 6, 1919, in Buffalo, N.Y.
Personal: married in 1945, five children, six grandchildren
Religion: Presbyterian Elder
Education: Cornell (BSEE, 1950) and Buffalo (MSEE, 1957) universities; also several honorary doctorates
First job: repairing radios in a Buffalo repair shop in 1938 for \$12 a week
Interests: gardening, sailing
Languages: English, French, German, technical reading proficiency in Russian
Pet peeves: venture capitalists; the U.S. Food and Drug Administration (medical device-regulating agency)
Management credo: create a hands-on, personal relationship in the workplace, grow on profits, stay out of debt
Personal hero: Thomas Edison
Favorite authors: Herman Melville, James Michener
Favorite composers: Bach, Vivaldi, Copeland
Favorite award: National Inventor's Hall of Fame
Patents: over 140 internationally (including 41 U.S. patents, more than half in his name only)
Memberships: National Academy of Engineering, Fellow in the following: New York Academy of Sciences, American College of Cardiology, Royal Society of Health (UK), American Institute of Medical and Biological Engineers; American Society of Angiology; the IEEE, among others
Personal philosophy: "Don't fear failure, don't crave success. Just immerse yourself in the problem and work hard. The true reward is not in the results but in the doing."

with his bride, Eleanor, a home economics teacher, who would become his laboratory assistant and his maker of bow ties as well. He worked a year as a telephone repairman before enrolling at Cornell University in Ithaca, N.Y. "After all that time in the dive-bombers with the ack-ack [anti-aircraft fire] bursting all around, you appreciate the change," he told *IEEE Spectrum*. "I was so grateful. I have repeatedly and vainly tried to imbue my children with the kind of appreciation that I had, just for the opportunity to sit, and hear, and learn. I don't think I ever got this across to them."

He gives Cornell credit for its emphasis on a broad engineering education steeped in mathematics, physics, and chemistry.

The breadth of his studies enabled him later to branch out into nuclear physics, electrochemical polarization of physiological electrodes, battery chemistry, the physics of welding, and more.

Soon, with several children to support, Greatbatch as a student needed to double his GI Bill income from the Federal government. He started as an electronics technician building receivers for what became the Cornell radio telescope at Arecibo, P.R. Eventually he inherited a job at the Psychology Department's animal behavior farm: doing instrumentation on around 100 sheep and goats (for blood pressure, heart rate, brain waves, and other measurements).

During 1951, Greatbatch used to share brown bag lunches on the farm with two New England surgeons, who were there on summer sabbatical. They described an ailment called heart block, which occurs when natural electrical impulses from the heart's upper chambers (atria) fail to reach the ventricles in adequate quantity. The result is irregular heartbeats that can cause shortness of breath and, in extreme cases, loss of consciousness and even death.

"When they described it, I knew I could fix it," Greatbatch recalled, "but not with the vacuum tubes and storage batteries we had then."

He did not know it at the time, but Paul Zoll in Boston made the first practical external pacemaker in 1952. About the size of a table radio, it could be plugged into household current. Though treatment was painful and damaged the skin, the device could save lives. Several years later, Earl Bakken, the founder of Medtronic Inc., developed a hand-held external pacemaker that was powered by batteries.

In the meantime, Greatbatch had returned to Buffalo to teach at the university as an assistant professor of electrical engineering. (Teaching was his original career goal.) He also did some work at the nearby Chronic Disease Research Institute. By then, around 1956, commercial silicon transistors had become available for US \$90 each, and Greatbatch, working for a doctor, was making a 1-kHz marker oscillator with one transistor to aid in the recording of fast heart sounds.

The oscillator required a 10-k Ω resistor at the transistor's base. "I reached into my resistor box for one but misread the colors and got a brown-black-green [of 1 M Ω] instead of a brown-black-orange," he said. When he plugged in the resistor, the circuit started to "squeg" with a 1.8-millisecond pulse, followed by a 1-second interval, during which the transistor was cut off and drew practically no current. "I stared at the thing in disbelief," he said.

This, he at once realized, was exactly what was needed to drive a human heart. The circuit was self-starting and its output

would remain constant despite drops in battery voltage. For the next five years, most pacemakers were to use a blocking oscillator with a United Transformer Co.'s DOT-1 transformer—all because he had grabbed the wrong resistor.

Barn exile

Buffalo was the site of the world's first local chapter of the Institute of Radio Engineers' Professional Group in Medical Electronics, which is now the IEEE Engineering in Medicine and Biology Society (EMBS). Greatbatch was a founding member. The group strove to attract equal numbers of doctors and engineers, and had a standing offer to send an engineering team to assist doctors on any instrumentation problem.

Greatbatch was on one team that had been summoned by William C. Chardack, chief of surgery at Buffalo's Veteran's Administration Hospital, to deal with a blood oximeter. The engineers could not help with that problem, but the meeting for the inventor was momentous: finally, after many previous attempts, he had met a surgeon who was enthusiastic about prospects for an implantable pacemaker. The surgeon estimated such a device might save 10 000 lives a year.

Three weeks later, on May 7, 1958, the engineer brought what would become the world's first implantable cardiac pacemaker to the animal lab at Chardack's hospital. There Chardack and another surgeon, Andrew Gage, exposed the heart of a dog, to which Greatbatch touched the two pacemaker wires. The heart proceeded to beat in synchrony with the device, made with two Texas Instruments 910 transistors. Chardack looked at the oscilloscope, looked back at the animal, and said, "Well, I'll be damned."

In a lab book entry in 1959, Greatbatch reflected on that moment: "I seriously doubt if anything I ever do will ever give me the elation I felt that day when my own two cubic inch piece of electronic design controlled a living heart."

The threesome (called the bow-tie team because none of them ever wore dangling ties, a convention Greatbatch upholds to this day) later put anesthetized dogs into complete heart block. As there was no heart-lung machine, the operating team had to work fast. The team closed off the large vessels, opened the heart, occluded the atrioventricular bundle with the tied suture, closed the heart, and reopened the artery—all within about 90 seconds.

"We were pretty naive about early pacemaker designs," their inventor observed. "We thought that wrapping the module in electric tape would seal it." The team soon found that the slightest void in the wrapping would fill with fluid and

short out the circuit. That first implant lasted 4 hours. Switching tactics, they began to cast the unit in a solid block of epoxy. Within a year, survival time rose to four months. It was time now, they felt, to look for a suitable human patient.

Greatbatch's then employer, Taber Instrument Corp., was loth to risk a million-dollar company on a perilous item like the pacemaker, so Greatbatch left. (But he did continue to work as an instrumentation consultant to the company, which was involved in some space shots of monkeys for the astronaut program.)

As with so many other inventions, an implantable pacemaker was the goal of several groups during the late '50s—from

wood-burning stove. There he made some basic discoveries. One was that uninsulated wires bond better with epoxy. He would glue components together, hand-solder the circuit, and fit it into a pack of batteries. This packet was then encased in a block of epoxy and cured overnight at a 37 °C. Several silicone coatings were applied and the unit was then trimmed with a scalpel. Serial numbers were imprinted on the uncured silicone.

In two years, on his \$2000 savings, he made 50 pacemakers by hand. Not all had the same design, and the number of batteries used ranged from three to 10. Forty of his units would go into animals as improvements were made. At the same time,

nium-powered pacemaker.

Greatbatch's first pacemakers to be successfully implanted in human patients consisted of pulse-generating circuitry linking two transistors, four to 10 zinc-mercury batteries of 1.35 V, and leads attaching the unit to the ventricle. Its lifetime rhythm was a 2-millisecond pulse of 5–8 V into the heart every second.

This device stood in for failed natural pacing and allowed a normal rate of invigorating fresh blood to circulate to all parts of the body. One of the inventor's "most gratifying realizations of what a pacemaker could do" came from watching grandparents interact with grandchildren. "With the pacemaker," he said, "grandpa could be in the mainstream again."

Medtronic man

In early 1961, at the Airways Hotel at the Buffalo Airport, Greatbatch signed a license for the implantable pacemaker with Medtronic Inc. Like Greatbatch, Medtronic's president Bakken was an EE who taught Sunday school. The struggling company operated out of a garage in Minneapolis and repaired TV sets when work was slow. As remuneration for his design, Greatbatch agreed to receive stock shares.

It was the beginning of Medtronic's Chardack-Greatbatch Pacemaker, which would dominate the field for the next decade, in spite of the innovations of many competitors. Greatbatch made monthly trips from Buffalo to attend meetings, sign off on drawings, and monitor production quality. He learned that a fingerprint on a transistor anode lead, for instance, would leave enough salt to corrode it.

Chardack "sold" the Medtronic device to the medical profession through his papers, case reports, and personal recommendations. Greatbatch credits him with much of the company's early success, but others credit Greatbatch, too. Said a competitor of the Buffalo engineer: "All salesman hustle their product, but he did his in an honest fashion."

Medtronic is still the world's top producer of therapeutic implantable devices, with sales of \$1.4 billion in 1994. Pacemakers accounted for 67 percent of that revenue.

But Chardack's job was no easy sell. At that time, it was anathema to most surgeons to leave anything in the body after surgery. But it turned out that the pacemaker was the ideal catalyst for the development of internal biomedical devices.

First of all, the heart had a high profile with the general public. Also, the pacemaker was relatively low risk. If the device failed, the patient did not necessarily die. (For the vast majority of patients, the pacemaker was to be a life enhancer rather than a life saver. For the critical patients of the early days, almost



▲ Cutaway of an early 1960s' pacemaker "explanted" from a patient shows the problematic zinc-mercury batteries and epoxy-encased circuitry. Improvements, many led by Greatbatch, have enabled today's pacemakers to frequently outlive millions of patients.

General Electric Co. to Swedish researchers. In Sweden, Ake Senning had attempted the first human implant late in 1958. The unit failed after 3 hours. A second unit worked for eight days before failing, and the patient had to wait for three years before receiving a satisfactory unit.

Perhaps Greatbatch owed his success to his demanding deadline. He had saved enough to feed his wife and three young children plus enough (\$2000) to devote himself full-time to his task for just two years.

"I put it to the Lord in prayer and felt led to quit all my jobs," he said. He retreated to his workshop, a barn heated by a

he was developing reliability procedures.

During 1960, starting on April 15, Chardack and his associates implanted pacemakers in 10 patients, most over 60 years of age. Two were children. All had complete heart blocks, so that without pacemakers they had perhaps a 50-percent chance of living more than a year.

The first patient lived 18 months. Another of the initial group was a young man who had collapsed on his job at a local rubber factory. After receiving a pacemaker, he retrained as a hairdresser and has only recently died, after being paced for 30 years, much of this time with a pluto-

anything was better than nothing.)

Circumstances were favorable biologically, too. Cardiac muscle is much easier to stimulate than, say, the smooth muscle of the bladder. Cardiac fibers are self-excitable and interconnected in a latticework so that an impulse applied locally to an atrium or ventricle will spread over the whole heart spontaneously, causing the organ to contract. In contrast, an impulse on the corner of a bladder will contract only that corner. (Only recently have clinical tests of systems for electrical stimulation of bladder control begun.)

But, even with these advantages, the pioneers of implants had a tough time. The body itself—warm, wet, and saline—is not hospitable to electronics. Greatbatch calls it more demanding than the deep ocean or space environment. Implanted devices must be rugged enough to defend themselves against onslaught from the body, yet at the same time be neutral enough not to counterattack and harm the inhospitable host.

"Many judgments had to be made by the seat-of-our-pants because there just wasn't much data around on the long-term behavior of materials in the body," the veteran inventor said.

Pacing on demand

Fixed-rate pacing was fine for the critical patient. But most people required only stimulation on demand, initiating a heartbeat only when it was needed. Such a sensing capability would prolong battery life and had been described in the literature.

Greatbatch's lab notebook states that his first successful breadboard of the implantable inhibited-demand pacemaker was completed in January 1965, resulting in Medtronic Model 5841, the first on the market (although Cordis Corp., Miami Lakes, Fla., had put out another type of demand pacemaker earlier).

Parts that did make it into a Medtronic unit were rigorously tested. Early transistors—from Texas Instruments, General Electric, and Transitron—had no consistent reliability. Greatbatch segregated them into beta (current gain) classes and put them through five cycles, from dry ice to heat soaking at 125 °C, for 500 hours.

In a shock test, any transistor that developed leakage or drifted more than one beta class was discarded. About 30 percent of the transistors were winnowed out, but none of the survivors was ever lost in a pacemaker.

In the early days, to bake transistors, Greatbatch set up two ovens in his bedroom. His wife, Eleanor, administered the shock test. "Many mornings," he said, "I would awake to the cadence of Eleanor 'tap, tap, tapping' the transistors" with a pencil.

For some months, every transistor used in Medtronic pacemakers was tapped in the Greatbatch bedroom in Clarence, N.Y.

Despite the pains taken to ensure reliability of componentry, many patients during the early years of artificial pacemaking died. Others were inconvenienced by unanticipated reactions or by the repeated surgery needed to change pacing units.

Aside from initial corrosion problems with electrodes, all the early pacemakers required difficult surgery. The chest had to be opened and electrodes sewn directly onto the surface or the middle layer of the heart. Ten percent of these poor-risk patients died from the surgery alone.

Later Chardack refined an existing technique in which a lead with a spring coil was inserted through a vein into the interior of the heart. This procedure permitted pacemakers to be implanted under local anes-



▲ The first implantable pacemaker in 1958, used on a dog, was wrapped in tape in hopes of protecting it against body fluid. Epoxy encasement ■■■ soon found to work much better.

thesia without opening the patient's chest.

Once the pacemakers were implanted, the body encased them in a collagenous sheath so tightly that when the units were taken out for new models or batteries, the Chardack-Greatbatch imprint and serial number were seen, backwards, on the collagenous growth. Said Greatbatch of the internal tattoo, "We felt this was really leaving our mark."

Heartbeat power

The great inventor admits that if he had not come up with the implantable pacemaker, someone else would have. "Most new developments are like that—not somebody getting a Eureka flash," he observed. What distinguishes him perhaps is his dedication to improving his invention.

This took several forms. One was giving advice freely. Recalled Walter Keller, who designed pacemakers in the 1960s for top rival Cordis Corp.: "We shared ideas. Since Bill was ahead of me, I got plenty of help from him."

Another was going outside his original training to develop better batteries. In a

1959 paper, Greatbatch had predicted a five-year average life for a pacemaker. In 1970, however, pacemakers were lasting an average of only two years. The problem was the power supply. Around 80 percent of those removed (called explants) were traced to a failed zinc-mercury battery, which used technology developed during World War II, modified in 1958 for the electronic wristwatch market.

Besides a relatively short shelf life, mercury batteries produced gas and therefore could not be hermetically sealed. Encasement in semipermeable epoxy was required. This did the critical job of keeping corrosive salt ions from the body out, but the electronics essentially operated immersed in distilled water. "Circuits in pacing drew so little current that the slightest problem could cause shunting," Keller recollected. And any contamination on the wiring would cause corrosion.

In 1968, Greatbatch had set out on two paths for power sources: one used halide cathodes with lithium as an anode, and the other used nuclear batteries based on plutonium 238.

Collaborating with Hittman Corp. of Columbia, Md., Greatbatch and a Hittman team designed a clinically successful plutonium battery that would have lasted the lifetime of even the youngest patients. But problems due to factors such as radioactivity and toxicity made them undesirable. Even a microgram ingested can be fatal.

In the early '70s, after numerous experiments with a variety of lithium batteries, Greatbatch and his colleagues adapted a lithium iodine power source to the high-reliability demands of pacemakers. It had been recently invented by James Moser and Allan Schneider. Batteries are complex systems to design well. In fact, a bad battery design ultimately caused Cordis Corp. to abandon pacemaking. Keller called Greatbatch's adaptation superb. "That guy, he's not only good, he's lucky!"

Greatbatch's confidence in this lithium battery was so great that he created a company to manufacture them. Today, the \$30 million company, which is run by his oldest son, Warren, still sells or licenses over 90 percent of the world's pacemaker batteries.

The lithium battery's advent has been called the most significant improvement for the pacemaker since its invention. Not only does the battery boast greater reliability and a higher power density than others, but it does not produce gas. Lithium batteries enabled pacemakers to be laser-welded in metal cannisters for a hermetic seal. At last circuitry and batteries could operate in a dry, moisture-free environment.

The battery innovation helped another top biomedical company. When Manny Villafana, a friend of Greatbatch's from Medtronic, was setting up Cardiac Pace-

makers Inc. (CPI) in Minneapolis, Greatbatch advised him that lithium batteries were too new and too risky for a company just starting out. But Villafana said he needed "something completely new" to establish the company.

For over a year, Greatbatch's firm sold him the lithium batteries without billing CPI. It also supported CPI in selling the device and in straightening out some technical issues. The alliance proved mutually successful. Lithium batteries are still the main power source in pacemakers, extending their average life beyond 10 years.

Tempting questions

During his career, Greatbatch's curiosity has lured him into many projects that failed. That category included his work on bone growth stimulation, closed-loop control of drug delivery, electronic control of infection, and creating orange trees impervious to frost damage. But his need to search for answers has also led him to tackle such problems as energy supply and, most recently, AIDS.

It was the energy crisis of the early '70s that induced him to clone plants and trees as a biomass source of fuel. He figured that 50 000 people using two fields of 61 km² could become independent of other forms of energy. He cloned a hybrid poplar tree in the sterile laboratory environment that could produce up to seven tons of dry wood per acre per year and would regenerate after being cut to stump level.

Greatbatch planted 40 000 of the trees, successfully composted two years of sewage sludge from a nearby town, and even modified his 1967 Dodge truck to run on wood alcohol. The goal was complete energy independence, but the end of the oil crisis and state environmental rulings put a damper on his efforts. He did, however, give cloned flowers to friends, including a miniature rose under 7 mm in diameter that was cultivated in a test tube; he named it "Rosemary Cloney."

Self-sufficiency and "the idea of getting something for nothing" were the reasons behind Greatbatch's building of a 380-W solar-powered canoe, in which he cruised around the Finger Lakes on his 72nd birthday. He submitted results of his 230-km voyage to the *Guinness Book of World Records*, hoping that someday its editors would establish such a category for the book.

"I'm sure my record will be quickly surpassed, but that doesn't matter," he said. "The joy of accomplishment is not in the results, but in the doing. It was great fun. Now maybe I can grow old gracefully."

Greatbatch (not himself the user of a pacemaker) is certainly not taking it easy. For the last decade he has investigated the human immunodeficiency virus. With John Sanford of Cornell University, he was able

'He's just a learner.
If something is new,
it doesn't bother him
a bit. Whenever
he does anything,
it's a total immersion.'

—Eleanor Greatbatch,
Wilson's wife of 50 years



to inhibit a similar viral replication in cats. The two were recently awarded U.S. Patent No. 5 324 643 for this work. To help his studies, he has bought a computer and modem to access the Internet from his home.

In praise of principles

Greatbatch likes to point out that "profession" has religious origins, deriving from monasteries, which were considered the repository of knowledge and where one "professed" his faith. Ethics and values are central. Money is not.

It is interesting to note that during the first 16 years of pacemaker manufacturing, no Federal regulation covered the monitoring of safe practices and trials. Practitioners—like Greatbatch—tackled the job scrupulously and did well.

Strengthening the engineering profession has been one of the inventor's ongoing commitments. Early in his career, in the nascent field of biomedical engineering, he insisted that engineers receive top billing in their professional journals while doctors would receive the marquis spot in medical journals.

He believes that engineers should participate in projects at both local and national

levels. Last summer, he lobbied on Capitol Hill for rules affecting international patents. At the state level, he feels biomedical engineers should be registered as professional engineers because they carry a social responsibility in helping to treat patients.

Always a booster of education, Greatbatch, friends note, has donated millions to schools, creating an engineering wing at local Houghton college, for example. Moreover, he has seen to it that his employees and their children seeking a university education have had their tuition and books paid for.

In spite of such great accomplishments, Greatbatch has no big ego. His children have a fancier life-style than he does. In person, he speaks softly, simply, and straightforwardly (like Gary Cooper, in a way). His wife Eleanor said, "He's just a learner. If something is new, it doesn't bother him a bit. Whenever he does anything it's a total immersion."

He learns mainly by talking to people, reading, and experimenting. Yet most of the time, she said, he works unhurriedly. Herb Mennen, an engineer and partner of Greatbatch's for more than 20 years, said, "He works a normal day. But geniuses do things differently."

To make an impact in engineering requires "complete immersion, a long time, maximal professionalism, and a subordination of those false values that the rest of the world deems so important," Greatbatch wrote in 1983. Citing the New Testament (First Corinthians 10:24), he said the other person's welfare should be more important than your own. "This is a shocking statement. American business doesn't run that way. But when a customer finds out you really mean it, most won't buy anywhere else."

Those themes are prominent in Greatbatch's favorite speech, which lasts about 2 minutes. He first delivered it in 1987 at a Clarkson University commencement in Potsdam, N.Y. Now he recites it by heart. Realizing that parts are preachy and that references to the Lord may fall upon unwilling ears, he nonetheless plans to continue giving the speech his way, he told *Spectrum* last November.

And so in fact he does that night at the IEEE/EMBS awards dinner, where both he and Bakken of Medtronic are being honored. Many in the audience, like the handful of students sitting at this writer's table, are not even sure who the elderly gentleman in the blazer and bow tie is.

But by the middle of the speech, no one is looking at the tines of the dessert forks. The speaker's sincerity has drawn everyone in. He urges the listeners, "Don't fear failure. Don't crave success," and reminds them that "the reward is not in the results, but rather in the doing." At least for a few minutes, an audience is spellbound. ♦

THE BEST STARTING POINT FOR CAREER development is your own company's system for filling job openings from within. In fact, if you are not aware of the system and how to benefit from it, you could already be missing out on a good opportunity for advancement.

Typically, the personnel department will post the job openings periodically. Companies realize that most frequently the best candidate for a newly available position is someone already on their payroll. Drawing on the pool of existing employees means less time and effort spent on training than if someone is hired from outside. So you as an employee may well have an edge over an outsider.

Job openings may be listed in the company newspaper, or posted on bulletin boards, or accessible through the company computer network. Do you read these listings? It amazes me how many people will read the daily newspaper's sports, financial, or arts sections, or the comics, but hardly ever scan the company's list of job openings. To get ahead, you should be reading these lists continually, as you can never tell when a better opportunity will present itself.

Actually, you ought to be in a constant job-search mode, both inside and outside your company. You should be constantly reviewing the job listings of trade journals and newspapers. You may even want to contact one or more professional search firms to do some searching for you.

What the job ads teach

Job ads will provide you with a wealth of knowledge about the job market and your chances for advancement at any given time. By studying your company's notices, you can quickly tell which divisions are hot and hiring—and which may be having difficulty because they have no openings.

How is your division doing? If it is hiring, chances for promotion in your present department are good.

Study the listings further. Do they identify the job level, type of engineer required, and pay level? Consider the experience and background being sought. The kind of training most of the job ads are seeking will indicate the background you may need to rise in the ranks. If all the openings are for chemical engineers and you are a software

engineer, you may find it hard to get ahead.

Compare your pay with the salaries on offer. If you are being underpaid, it's time to move on. If the level is comparable, you can be satisfied, at least for the time being.

Also review the salaries for jobs one level above yours. Would you like a raise and a promotion? Well, how will you find out whether you qualify unless you go for an interview? Remember, your supervisor may be restricted in the salary increase he or she can offer you, but a different supervisor might be more at liberty to give you a raise because

THE IN-HOUSE SPRINGBOARD TO SUCCESS

Your company's help-wanted ads can lead to a better job right under your nose

in that other department you would be a new hire.

As you study the ads, determine which of the divisions have openings and what you would be working on if you joined them. What products are under rapid development? Which divisions and products are stagnating? Is there any chance of transferring to a new division or product line and picking up a promotion on the way over?

A word of caution about your own company's job openings: the typical organization has an internal policy regarding promotions. Of course, it wants to put the most suitable person into a position, not just whomever the supervisor wants. So the latter will frequently be required to advertise that the position is open and to interview all likely candidates.

What this often means is that an opening will be posted even if the boss already has someone in mind for the job. Some research is therefore of the essence even before you respond to a job listing at your company. Try to find out if someone is already in line for the vacancy. And when you

JOHN A.
HOSCHETTE
*Loral Infrared and
Imaging Systems*

Adapted from Chapter 5 of *Career Advancement and Survival for Engineers* by John A. Hoschette (with permission, John Wiley & Sons Inc. [800-225-5945], 1994, 200 pp., \$39.95 cloth, \$15.95 paper). For earlier adaptations from this book, see *IEEE Spectrum*, November 1994, pp. 96-99; December 1994, pp. 42-44; and February 1995, pp. 56-58.

are finally interviewing, ask the supervisor the obvious question: "Is anyone interviewing who is presently in your group?" If the answer is yes, that person is more than likely the best candidate and it is a "done deal," as they say.

Besides studying your own firm's job listings, you should constantly be checking the job ads of your company's competitors in the trade journals and newspapers. Are they hiring? What type of people are they looking for? What are they willing to pay employees with a similar background to yours? Which are your competitors' growing and expanding divisions and product lines? Are they looking for your level of background and experience or for some other type? All these questions can be answered through studying the job listings. And all this information is important for your career development.

The next question to arise is, "What do I do if I find something?" The answer is straightforward.

that you can say that should do more good than harm to your career. First, you can say that you are happy where you are and have no desire to leave, but you heard of this opportunity and thought you would just check it out. After all, it seems a wonderful opportunity, and no one aspiring to rise professionally would fail to look into it.

Alternatively, you might shower your supervisor with compliments. For example, you can point to the great job she or he did developing you. You might argue that the chief reason you feel you stand a chance for a better opportunity is the excellent training you've received.

Still another approach, if you are unhappy with your present position and rate of growth, is to be frank and open. Tell your supervisor that you see little opportunity where you are and you feel that you must explore the options.

Candor is likely to elicit one of two reactions, both helpful. You might be told that there really is little hope for you in this group and you should probably look elsewhere. This is valuable information about how your supervisor perceives you and what your real chances for advancement are. It confirms your decision to search for other work.

The other reaction is an expression of concern and a declaration of how much you are wanted and how valuable you are. You have now opened the door to further discussions about your possible advancement. Seize the chance to outline your career objectives, and with any luck, the two of you will work out a plan to get you what you want.

In other words, use the opportunity to start planning your next promotion together. If the rapport between the two of you is good, you might point out that it's easier for your boss to give you the promotion than to spend

time on training a new person.

Whatever you are told, keep on tracking down job opportunities. If one arises within your company, be sure you inform your supervisor before you talk to the person doing the hiring. It is professional courtesy, and besides, it will only end up hurting you if someone else leaks the news.

Of course, discretion is always the better part of valor. Job shopping should be a very low-profile activity. If you are too visible and start interviewing in too many places, your ambition can backfire. Your supervisor will quickly find out what you are doing and want to know why. Do not volunteer any information unless you are asked directly. And don't discuss your plans with co-workers—they could go running to the boss the minute you leave their office.

When you go for the interview, you had better



PAUL ANDERSON

Go and check it out. You should check at least once a year for other job opportunities through some type of job interview.

There are three reasons why this matters. First, it will keep your interviewing skills sharp and your résumé updated. Second, it may bring you a better opportunity for promotion. Third, you may find out that your job is not so bad after all. In any case, you benefit from the experience and lose nothing—well, it should be nothing.

Many people react to the reasons for pursuing career advancement enumerated earlier with, "That's great, but if my supervisor finds out, I'll lose my job." If this is really the case, I strongly recommend you make a change immediately. You do not want to be working for that type of person.

If your supervisor does find out that you are exploring new opportunities, there are several things

have good answers to some tough questions. The first is usually: "Does your present supervisor know you are interviewing?" An excellent answer is that your supervisor does know and does not want to stand in the way if this is really a good career move.

A second and equally difficult question is: "Why do you want to leave?" One response is to say that you are looking for a better opportunity and that you thought this might be one. Whatever else you do, do not speak negatively about your present position. Act as if anything you say about your supervisor or group will immediately be spread all over the company.

Remember that soon after you leave the interview, the first thing the hiring supervisor will do is call your present boss. And how that person responds can make or break your chances.

If your present chief thinks highly of you, he may respond with, "He is a great employee and I don't want to lose him." Whereupon the hiring supervisor will probably want you all the more. But a response such as, "He is a marginal performer and I'd like to get rid of him," could end everything immediately.

The important point here is that if you don't know how your supervisor will react, you are taking a big risk. You should know what that reaction will be before you spend time interviewing. Keeping on good terms with your boss during this whole process is essential.

But being on poor terms with the person over you need not mean the end of a job switch within the company. The effect of a poor relationship could be good or bad—I have witnessed both dénouements.

On occasion supervisors want to get rid of someone. Rather than fire whoever it is, they find the person new opportunities and may even pass along great performance recommendations.

At other times a supervisor seizes the opportunity to get even and on purpose underrates the employee's performance and spoils any chance at advancement. If your relations with your supervisor are poor, you might want to ask outright how he or she would react before you go through all the effort to switch jobs within the company. Watch the reaction. If it is a "get even" response, you will have to deal with it. You cannot ignore it.

Bidding up the job offer

After you get a job offer, your work is still not done, regardless of whether the offer comes from inside or outside your present company. In either case, the ideal is to get your present supervisor to make a counteroffer in the hopes of keeping you.

You should tell your boss what's up. Explain why the offer appeals to you and

why you intend to leave if no counteroffer is made. The intent here is to try to extract an even better deal from your present supervisor. (If you would prefer not to leave at all, you must definitely give your boss a chance to match the offer.)

Ask your supervisor to come up with at least as good an offer. It is surprising how fast some can move and how much they can counteroffer when afraid of losing a key performer. Sometimes another offer helps build a case for promoting you. If someone else thinks you promotable, why shouldn't your present supervisor think so, too? It may be all that is needed to push some supervisors to action. It hurts their ego to know that someone else in the company is trying to steal their people.

If you get your supervisor to counter the offer, your battle is still not over. Take that offer and see if the new supervisor can do better. Your goal is to get both supervisors to offer absolutely the most they can. You repeat this process until neither of them can offer any more. At this point you win.

Some engineers feel this is unethical or not normal. To this I say: look at other professions, sports in particular. Athletes even go as far as hiring agents to negotiate job opportunities for them. Actors, actresses, lawyers, and nearly every other professional person do the same thing. Knowing how to negotiate is essential for career advancement.

Comparing the prospects

WHEN THE BEST AND FINAL offers are in, you need to consider career aspects other than status and salary. It's the best of all possible worlds if you change jobs for a promotion and stay within the company. You keep your seniority and your vacation and retirement benefits. Studies show that an engineer who stays with one company until retirement will in most cases leave in better shape than one who has changed jobs. This is so even if the person changing companies has had larger pay raises.

Remember, more than a simple pay raise is involved when you consider leaving a company. Leave and you lose vacation and retirement benefits. You may also incur extra expenses. For instance, you may have to drive farther to work or move out of state. In the latter case, there will be the costs of changing your car insurance, place of residence, driver's license, and real-estate fees, just to name a few. Is any of the raise left after you pay all the new expenses? How will your retirement benefits be affected? For example, a 3 percent raise inside the company may be equivalent to a 6 percent increase outside.

Another point to weigh is that at the new company you will be starting over. You cannot expect a large raise any time

soon. It may take you over a year to re-establish your position and your performance. So, if you get a raise when leaving, make sure it's large enough. It may be a long time before you get another.

When your move is blocked

If your present supervisor tries to block your move, you have several options. First, suggest a convenient transfer date some time in the future and try to get your supervisor to agree to it. Let it be known that you are not going to leave the company high and dry. You should be able to work out some gradual transfer plan.

If your supervisor continues to fight you, you will have to play hardball. You point out what your reaction will probably be over time. At first, you will go on working hard, but after a while you will probably lose interest. It's hard for you to give it all you've got when you gave up a promotion and raise simply because your supervisor didn't think you should get it.

Explain that holding you back is not good for either of you or the company in the long run. Nobody wins in this type of situation. Or you might try volunteering your help in finding and training your replacement. This eases the transition.

If you win your supervisor round and do accept a raise and promotion elsewhere in the company, there is still a protocol to follow. Above all, thank your present boss for all past help. Point out all the good things your new supervisor liked in you, and indicate that you qualified for the new position in part because your old supervisor did so much for your development.

Never leave on bad terms. The ill will could come back to haunt you.

Homework

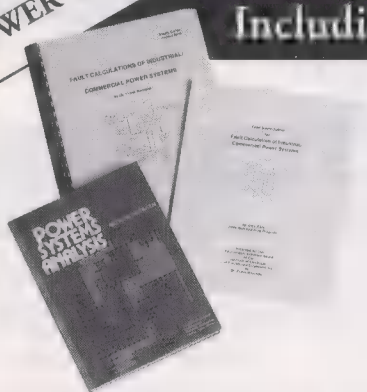
- Find out how your company's system of posting job openings works.
- Study the help-wanted notices. Do you know all the codes? What do the ads tell you? Which divisions are hot, which are not?
- Study the job ads in trade journals. What are they looking for and how much are they willing to pay?
- Pick a job opening at your company and go on an interview. ♦

John A. Hoschette is a staff engineer with Loral Infrared and Imaging Systems, Lexington, Mass. He has over the last 18 years worked in all phases of engineering projects, including the technical direction of several multi-million-dollar programs. He is also a member of the National IEEE Career Maintenance and Development Committee and of the Boston Section of PACE. His book is based on course material he developed at his company on career development for engineers. He can be reached on the Internet at: john_hoschette@liris.loral.com.

**A MUST FOR
ALL POWER ENGINEERS!**

NEW...from IEEE's Educational Activities

**A Self-Study Course for Every Power Engineer,
Including Plant and Utility Engineers at All Levels.**



FAULT CALCULATIONS OF INDUSTRIAL/ COMMERCIAL POWER SYSTEMS

By Dr. Frank J. Mercede, P.E., Widener University

The purpose of this self-study course is to review the fundamental theory and practical requirements to perform short-circuit calculations on industrial and commercial power distribution systems, according to Chapter 6 of the IEEE Red Book (i.e., ANSI/IEEE Standard 141-1986). The results of these calculations are then used for the proper selection of short-circuit capabilities of low and medium voltage power circuit breakers and fuses. This course should be particularly useful to power engineering students and practicing power engineers who are employed as plant engineers with heavy industrial and commercial customers, utility engineers who work at the distribution level, and power engineering consultants. This course is a perfect complement to, and extension of the subject matter as presented in the IEEE Brown Book, the Red Book and the Gray Book.

Includes: Comprehensive study guide/answer book, final exam, textbook (*Power Systems Analysis* by Arthur Bergen, Prentice Hall), IEEE Red Book ANSI/IEEE Standard 141-1986, 8 CEUs, Certificate of Achievement upon completion.

If you already have the IEEE Red Book, the self-study course is available without the text. Use Order Number HL0464-8-PZP ISBN 0-7803-0363-6. IEEE Member Price: \$219.00 Non-member Price: \$359.00

From this course you will learn. . .

- ◆ The essential background including terms and definitions necessary to fully understand the process.
- ◆ Practical issues to consider for your application.
- ◆ How to perform fault calculations for industrial/commercial power systems.

Important features include:

- ◆ Six review units on the essential background in steady-state ac circuit analysis, ac power, balanced three-phase systems, basic modeling, per-unit computation, and symmetrical components;
- ◆ Numerous examples of short-circuit calculations for balanced 30 faults at low and medium voltage buses;
- ◆ Explanations on the basis and selection of multiplying factors to determine asymmetrical short-circuit (momentary and interrupting) duties;
- ◆ Examples of unbalanced short-circuit calculations;
- ◆ Numerous illustrations to explain all of the topics.

Some of the questions addressed by the course include:

- ◆ Can I still perform a short-circuit study with incomplete data?
- ◆ How do I model the utility for short-circuit calculations?
- ◆ How do I include the effects of large groups of small horsepower induction motors?
- ◆ What is the difference between interrupting duty for a medium voltage bus versus interrupting duty for a low voltage bus?
- ◆ What is the difference between a "remote" fault and a "local" fault?
- ◆ What is the basis for the 1.6 multiplying factor to calculate asymmetrical first cycle (momentary) duty?
- ◆ What is the meaning of symmetrical-rated circuit breakers for low and medium voltage buses?

**IEEE Member Price \$259.00 • List Price \$399.00
Order Number: HL4598-PZP — ISBN: 0-7803-0350-4**

FOR FASTEST SERVICE

CALL TOLL FREE (IN USA) 1-800-678-IEEE • FAX 1-908-981-9667 • PHONE 1-908-981-0060



IEEE

Presents Its 1995 Plans for Conference Proceedings



THE 1995 IEEE PREPAID ORDER PLAN (POP)

Subscribe to the 1995 POP plan and you'll get about 130 major 1995 IEEE conference proceedings — for \$11,995! This is the standard plan libraries have received for decades.

THE 1995 IEEE PREPAID ORDER PLAN PLUS (POP PLUS)

The 130 major conferences discussed above plus about 80 new 1995 IEEE conferences, workshops, and symposia in rapidly-emerging technologies — for \$16,975! POP Plus is all the 1995 IEEE conferences, in electrical engineering and computing in one plan.

SUBSCRIBERS TO BOTH PLANS RECEIVE:

- about a 38% savings off the total list prices of individual conferences
- a quarterly listing of the proceedings they should have received

To order or for more information, contact:
Robert S. Hohwald
(phone) 1-908-562-3999
(fax) 1-908-981-8062
(e-mail) INTERNET:r.hohwald@ieee.org



IEEE
THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.
445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA

EMPLOYMENT OPPORTUNITIES

Organizations seeking engineers and scientists describe their various openings in the following advertising section

In order to conform to the Age Discrimination in Employment Act and to discourage age discrimination, IEEE may reject any advertisement containing any of these phrases or similar ones, "recent college grads," "1-4 years maximum experience," "up to 5 years experience," or "10 years maximum experience." IEEE reserves the right to append to any advertisement, without specific notice to the advertiser, "Experience ranges are suggested minimum requirements, not maximums." IEEE assumes that, since advertisers have been notified of this

policy in advance, they agree that any experience requirements, whether stated as ranges or otherwise, will be construed by the reader as minimum requirements only. While IEEE does not ban the use of the term "entry level," its use is discouraged since, to some, it connotes an age rather than an experience designation. IEEE accepts employment advertising to apprise its members of opportunities. Interested parties should be aware that the political and humanistic values of certain advertisers may differ from their own. IEEE encourages employers to offer salaries that are competitive, but occasionally a salary may be offered that is significantly below currently acceptable levels. In such cases the reader may wish to inquire of the employer whether extenuating circumstances apply.

To place an advertisement in *Spectrum's* Employment Opportunities section, contact the nearest *Spectrum* sales office

212-705-7760 New York	508-255-4014 Boston	708-446-1444 Chicago	415-386-5202 San Francisco	310-649-3800 Los Angeles	404-256-3800 Atlanta	214-553-9896 Dallas	303-670-3749 Denver
--------------------------	------------------------	-------------------------	-------------------------------	-----------------------------	-------------------------	------------------------	------------------------

For production/mechanical information contact Martin Barbieri Advertising Production Manager, 908-562-6334

IEEE Spectrum Advertising Dept., 345 E. 47th St., New York, N.Y. 10017

FACULTY OF SCIENCE AND ENGINEERING

SCHOOL OF ENGINEERING ACADEMIC POSITIONS IN ENGINEERING (Convertible)

The School of Engineering commenced operation in January 1992 with the formation of a Joint Faculty of Engineering between Flinders University and the University of South Australia, and the appointment of its Foundation Professor of Engineering. The School offers undergraduate and postgraduate degree programmes in Biomedical Engineering, Electrical and Electronic Engineering, and Information Technology and Telecommunications.

Modern, well equipped teaching and research facilities are being progressively established and the School is set to grow rapidly over the next 3 years. The University is seeking high calibre academic staff, with a demonstrated commitment to teaching and research, who will assist in shaping this future.

A number of positions at the following levels are available for a term of three years, but may be extended for a further period and/or converted to continuing positions.

Ref 950211	- Senior Lecturer	(from 1 July 1995)	A\$51 692 - A\$59 605pa
Ref 950221	- Senior Lecturer	(from 1 Jan. 1996)	A\$51 692 - A\$59 605pa
Ref 950231	- Lecturer	(from 1 Jan. 1996)	A\$42 000 - A\$50 111pa

Strong academic qualifications, preferably at PhD level, or equivalent industrial or research experience, and excellent written and oral English communication skills required for all positions. The senior appointees will have a substantial record of achievement, and be expected to assume a leadership role in Biomedical Engineering or other key areas including Communications Engineering, Digital Systems and Micro-computers, Signal Processing, and Electrical Machines and Drives.

Selection criteria and further information regarding opportunities and duties associated with these positions may be obtained from Professor Andrew Downing, Head, School of Engineering, phone (618) 201 3603, fax (618) 201 3618 or email egard@cc.flinders.edu.au. Applicants must indicate at which level they are seeking appointment, which at Lecturer level, is not normally made above A\$46 946pa.

Applications, addressing the selection criteria, quoting the reference number, and giving full details of qualifications and experience together with the names, addresses and facsimile numbers of three referees of whom confidential enquiries may be made, should be lodged, in duplicate, with the Manager, Human Resources, Flinders University, GPO Box 2100, Adelaide SA 5001, Australia or fax (618) 201 3131 by 31 March 1995.

The University ☐ right not to make an appointment
☐ to invite applications.

Equal Opportunity is University Policy.

**FLINDERS
UNIVERSITY**
ADELAIDE • AUSTRALIA

AK 59763

WE SET THE TRENDS, THE PACE AND THE STANDARDS.

General Instrument is the pioneer and recognized world leader in the ongoing development of HDTV, satellite TV encryption, and broadband digital compression technologies. We are creating a new frontier combining ATM and Cable TV networks to bring interactive services into the home.

Our mission is to find talented engineers to join us in developing these exciting new technologies. We have many opportunities for Senior Engineers with backgrounds in:

Digital Design
Systems
Firmware
Networks

VLSI
Software
Test
Video/Audio

Please forward your resume to: *General Instrument, HR Dept., CODE IEEE3, 6262 Lusk Blvd., San Diego, CA 92121. Or Email to: jobs@gi.com* EOE.

GI General Instrument


Associate Director for Engineering

Lawrence Livermore National Laboratory (LLNL), one of the nation's leading research and development organizations, has an opening for an Associate Director (AD) for Engineering. This position is part of the Laboratory's senior management team and reports to the Director. The AD will lead 2100 engineers, technicians and administrative staff in current engineering support activities in partnership with the very broad research and development activities of the Laboratory. The successful candidate must have a vision of the future, long-term engineering technologies needed, and be proactive towards ensuring the Programs' success in state-of-the-art applied research.

Requirements include an advanced degree or equivalent experience in Engineering or related disciplines, evidence of creativity, entrepreneurial skills and innovative thinking, and experience and demonstrated superior achievement in engineering sciences or related disciplines. Qualified candidates must also have demonstrated successful leadership in a senior level position equivalent to that of an associate or deputy associate director in a high technology environment. Knowledge of the Department of Energy and other federal programs in the engineering sciences, participation on national and international research and advisory boards, and experience managing in a matrix management environment is desired.

LLNL offers a challenging work environment and a competitive salary/benefits package. Qualified individuals are invited to send their resumes to: Kristine Kansa, Recruiting and Employment Division, Lawrence Livermore National Laboratory, PO Box 5510, L-725, Dept. AJSP315KK, Livermore, CA 94551. U.S. Citizenship is required. We are proud to be an Equal Opportunity Employer. M/F/D/V.

University of California

 **Lawrence Livermore
National Laboratory**

Honeywell

Micromachined Sensors & Actuators

The Honeywell Technology Center is a multidisciplinary industrial R & D center, located in suburban Minneapolis, carrying out innovative R & D in the areas of sensor, microelectronics, controls, signal processing and software.

We presently have several openings for researchers in the area of micromachined sensor and actuator development for application to a wide range of Honeywell businesses. Current development programs that these positions would impact include:

- Precision pressure sensor development for aviation air data and industrial pressure transmitters.
- Inertial - grade accelerometer development for aircraft navigation and other commercial applications.
- Micromachined optical tunable filters for industrial environmental gas analysis.

A successful candidate should have a PhD in EE or Physics with extensive hands-on semiconductor fabrication technology experience. Some experience with finite element modeling is also desired.

For consideration, please send a resume to: **Esther Saarela, Honeywell Technology Center, 10701 Lyndale Ave. So., Bloomington, MN 55420, (612) 956-4716.** Equal Opportunity Employer M/F/D/V.

PHOENIX

SR. TEST ENGINEERS/ PRODUCT ENHANCEMENT ENGINEERS

Microchip Technology Incorporated is a worldwide leader in the design and manufacture of field programmable RISC microcontrollers and specialty memory products. Join us in Arizona where our environment is challenging and our employees are valued.

Utilizing your BSEE and 5+ years semiconductor experience, selected candidates will provide engineering development and test support for new product introductions and/or midrange Microcontrollers in the Product Enhancement Engineering area. Qualifications for the Test Engineer opportunities include experience with Sentry S10/S21 or Credence STS testers, understanding of qualifications, characterizations and production releases along with a minimum of 5 years experience writing code. Product Enhancement Engineering candidates must have knowledge of Trillium Micromaster II, basic design and device physics, and UNIX or VAX/VMS. Both positions require a background with C++ and Pascal.

We offer an excellent compensation and comprehensive benefits including relocation package. Please send/fax your resume to: **Microchip Technology Inc., Human Resources, Job Codes 353VW/1326EM, 2355 W. Chandler Blvd., Chandler, AZ 85224. Fax: (602) 786-7790; Job Hotline: (602) 786-7777.** Microchip has a strong commitment to the principles of diversity and are proud to be an equal opportunity employer.



MICROCHIP

ISSA/NSA POLY

USE YOUR "TICKETS" FOR FASTER CAREER GROWTH

Put our 27+ years experience placing technical professionals to work for you. All fees paid. Nationwide opportunities in Communications, Defense, Intelligence, Computer, Satellites and Analytical Sciences. If you earn over \$35,000, we have a better, more rewarding job for you ... right now. U.S. citizenship and ISSA/NSA POLY desirable. Call (301) 231-9000 or send your resume in confidence to: Dept. EA-13EB or FAX to: (301) 770-9015.

WALLACH associates, inc.

Technical and Executive Search

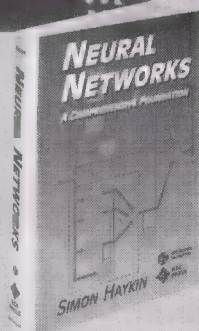
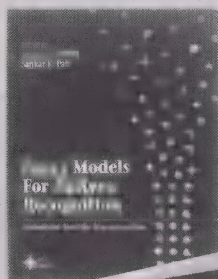
Washington Science Center
6101 Executive Boulevard
Box 6016
Rockville, Maryland 20849-6016

NEW...

FROM THE IEEE



PUBLICATIONS IN
FUZZY LOGIC
FROM THE
WORLD'S MOST
COMPREHENSIVE
PUBLISHER IN
ELECTRICAL,
ELECTRONICS,
AND COMPUTING
ENGINEERING



FUZZY MODELS FOR PATTERN RECOGNITION

Methods That Search for Structures in Data

edited by James C. Bezdek, University of West Florida,
and Sankar K. Pal, NASA Johnson Space Center

Beginning with Lotfi Zadeh's original 1965 article on fuzzy sets, the editors of this important new book take you chronologically through categories on the evolution of fuzzy algorithms for feature analysis, clustering and classifier design, and image processing and vision. Each category is divided into topics which the world's leading researchers on the subject discuss everything from theory to the practical application of a pattern recognition system in a design problem.

"...one of the best written, concise discussions of fuzzy set theory and its applications to pattern recognition that I have ever seen."

— Frederick E. Petry,
Tulane University.

IEEE Member Price: \$60.00

List Price: \$74.95

1992 Hardcover 552pp

IEEE Order No. PC3178

ISBN 0-7803-0422-5

NEURAL NETWORKS

A Comprehensive Foundation

by Simon Haykin,

McMaster University Communications Research Library

Co-published with Macmillan and IEEE Computer Society Press

Written from an engineering perspective, NEURAL NETWORKS provides a comprehensive, up-to-the-minute treatment of the field, complete with incisive examples, challenging problems and computer-oriented experiments. The material is presented in a clear and easy-to-understand style, with derivations as complete and simple as possible. It introduces common models and algorithms in a thorough and straightforward manner and is filled with examples so that readers can see real applications of neural networks.

"The best engineering-based text by a considerable margin..."

— James A. Anderson,
Brown University

**For IEEE
Members Only!**

IEEE Member Price: \$56.00

List Price: \$69.95

1994 Hardcover 720pp

IEEE Order No. PC4036

ISBN 0-02-352761-7

ALSO AVAILABLE, EXCITING VIDEO TAPES ON FUZZY LOGIC!

FUZZY LOGIC

Advanced Concepts & Structures

presented by Lotfi Zadeh, Electrical Engineering
Department, University of California at Berkeley

Have you always wanted to know the ideas underlying fuzzy logic? Now, the "inventor" of fuzzy logic, Lotfi Zadeh, has prepared this course specifically to teach you the concepts and structures underlying fuzzy logic.

IEEE Member Price: \$89.95

List Price: \$129.00

1992 2 hours 1 VHS tape

IEEE Order No. HV2584 (NTSC)

ISBN 0-7803-0333-4 (NTSC)

INTRODUCTION TO FUZZY SET THEORY AND FUZZY LOGIC

Basic Concepts and Structures

presented by Enrique Ruspini,
Artificial Intelligence Center, SRI Intelligence

Learn how to use the basic tools, concepts and structures of fuzzy sets and fuzzy theory. This video will help you understand the nature and characteristics of fuzzy logic and applications.

IEEE Member Price: \$89.95

List Price: \$129.00

1992 2 hours 1 VHS tape

IEEE Order No. HV2576 (NTSC)

ISBN 0-7803-0332-6 (NTSC)

FUZZY LOGIC

Technology and Applications

The one, current source for the
newest applications in fuzzy logic!

This 1994 volume details the recent advances in the design, applications, and foundations of fuzzy logic. This volume is the key source where a professional entering or working in the field of fuzzy logic can find the best practical papers.

IEEE Member Price: \$48.00

List Price: \$59.95

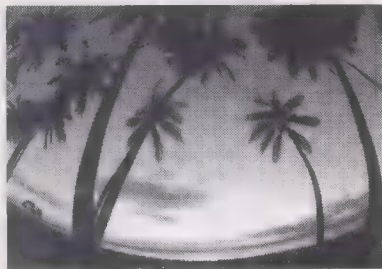
1994 Hardcover 470pp

IEEE Order No. CR1016

ISBN 0-7803-1383-6

FOR FASTEST SERVICE, CALL 1-800-678-IEEE (1-908-981-0060 OUTSIDE OF THE U.S.) OR FAX: 1-908-981-9667
The Institute of Electrical and Electronics Engineers, Inc. • 445 Hoes Lane • Piscataway, NJ 08855-1331 USA

Here in Orlando, the climate is ideal for growth...



Right now in Orlando, Florida, Martin Marietta Information Systems is laying the groundwork for a new generation of real-time systems and solutions. We already lead the industry in delivering the core technology that drives computer image generation for simulation and training. And we're quickly expanding our lead through the development of sophisticated entertainment and virtual reality applications.

In this climate, you can leverage your technical expertise in many exciting ways all while enjoying the year-round amenities of life in central Florida. Here are some of the opportunities you'll find here:

Software Systems Architect – Virtual Reality

Play a key role in the development of innovative 3D graphics entertainment and virtual reality products for a wide range of commercial markets. In this capacity, you will design and develop Windows NT device driver software and support the conceptual design of future products. This will involve performing low-level software and hardware integration using DMA and interrupt-driver services. Hands-on experience using C and assembly languages to develop Windows NT device drivers, a related BS degree and at least 5 years' experience are required.

Senior ASIC Designer

We seek a proven leader to direct the work of a large ASIC development team. The ideal candidate has a BSEE

or equivalent with at least 8 years of experience in the following areas:

- Designing high-speed digital ASICs (standard cell and/or gate array), including packaging, wafer sizing, floor planning and place-and-route
- HDL and logic synthesis tools
- Managing ASIC and CAE tool vendors
- Real-time computer image generation hardware algorithms, including design and verification
- Programming with Unix and C
- Full custom ASIC/MCM design a plus

ASIC Project Engineer

You will provide technical direction for complex ASIC developments. This will involve planning, directing and mentoring ASIC design technology with a focus on improving team productivity. We'll also count on you to improve the overall ASIC development process and first-time silicon design success. To qualify, you must demonstrate your ability to enhance engineering productivity while leading large technical projects related to ASIC development and technology migration. You should also possess an advanced degree in a technical discipline and experience with the following:

- Vendor management
- Custom VLSI design
- SMT packaging
- ASIC/FPGA technology
- CAE/CAD support tools
- HDL top-down design
- Hardware synthesis technology and tools

Join Martin Marietta in Orlando ... where the climate is ripe for new professional and personal options. Please fax your resume to Dept. OA9503 at (703) 821-3521 or mail to our central staffing office at: Martin Marietta, Dept. OA9503, P.O. Box 8048, Building 10, Room 1019, Philadelphia, PA 19101. An equal opportunity employer.

MARTIN MARIETTA

INTRODUCING THE 1995 IEEE ALL-SOCIETY PERIODICALS PACKAGE

**WHERE TECHNOLOGY
IS EXPLODING
TO SERVE MANKIND**

Our All-Society Periodicals Package Brings You These Major Benefits:

► **CORE COLLECTION IN THE FIELD**

IEEE periodicals cover every aspect of electrical engineering, electronics and computing completely and authoritatively. By subscribing to the All-Society Periodicals Package, you'll maintain the core collection of your library by receiving the major work in the field.

GET OVER 1/3 FREE

The 1995 Package costs \$11,995 for our 92 top periodicals. If you subscribed to each one individually, you'd pay \$20,106. That's a savings of \$8,111 or over one-third!

► **FREE 1995 INDEX**

With our All-Society Package you'll get the new 1995 two-volume *Index to IEEE Publications* — a value of over \$500 — free.

For a free brochure or to order call toll-free in the U.S.:

1-800-701-IEEE

(1-908-981-0060 outside the U.S.)

or fax:

1-908-981-9667



**THE INSTITUTE OF ELECTRICAL
AND ELECTRONICS ENGINEERS, INC.**

R&D Telecommunications Engineers

At GTE Laboratories, we have assembled one of the strongest groups of researchers and developers in the world to support GTE's telecommunications businesses. We are the largest local exchange telephone company and the second largest mobile service provider in the U.S. We currently seek Telecommunications Engineers in a variety of specialties.

Senior Software Engineer

You will incorporate models, planning techniques and algorithms into various engineering applications. In this capacity, you will optimize analog and digital cellular/personal radio communications networks by providing software development, maintenance, field and technical support for scientific/engineering applications running on UNIX workstations under X Windows and Motif. Candidates must have a BS/MS in EE or CS and 3-5 years' experience in C-language software development, maintenance and support in a UNIX/X Windows environment. Familiarity with radio technology and/or cellular systems desirable. Some travel required. **Box IJK-1**

R&D Software Engineer

You will implement management solutions for the evolving telephony access network and be involved in the prototyping and initial release of UNIX-based client server systems. The emphasis will be on developing a network element manager to administer fiber-in-the-loop and next-generation digital loop carrier systems. Strong programming skills in C, C++ or another object oriented language is essential. Experience working on relational databases, X/Motif and GUI development desirable. A BS/MS in CS or related discipline with related experience preferred. **Box ILA**

Data Communications Engineer

You will investigate the capability of emerging technologies such as switched and fast Ethernet, frame relay, ISDN and ATM to provide integrated video and data services to business and residential users. To succeed, candidates must have a BS/MS in EE, CS, Mathematics or equivalent and 5-10 years' experience in data communications R&D. A solid knowledge of LAN/WAN protocols and hands-on expertise with LAN/WAN test instrumentation routers, switches and other key network elements essential, as is some experience writing real-time device drivers. **Box IRO**

Systems Software Engineers

Two positions are available in DALLAS for experienced Systems Software Engineers to join the Intelligent Network (IN) project. One position is concerned with the design and development of IN based telecommunication services on prototype and commercial systems. The other position will investigate service control architectures for broadband applications, in particular, the design and development of service control interfaces to broadband network elements. A MS in CS or EE with 5 years' experience in the telecommunications industry (Switch, SS7, ISDN and Intelligent Network experience particularly desirable) and in software development in a UNIX environment required for both positions. **Box IPO**

Principal Engineer—RF Propagation

This hands-on professional will work closely with client organizations to support field implementations of digital cellular technology. This will involve developing rf propagation modeling tools for use in a state-of-the-art radio planning software package. To succeed, candidates must have extensive R&D experience in mobile and wireless communications systems, with an emphasis on propagation measurements and modeling at 800 and 1800 MHz. An MS/PhD in EE and a proven track record of hands-on contribution in a results-oriented R&D environment is essential, as is 10 years' experience in the development of digital communications systems, including 5 years' with mobile or cellular communications systems. An in-depth understanding of existing cellular communications technologies and proposed technologies for cellular and PCS bands, as well as a thorough knowledge of digital radio access techniques for mobile, wireless and personal communications highly desirable. Strong written/verbal communication skills a must. **Box IJK-3**

Telecommunications Systems

You will be involved in the delivery of advanced video, voice, data and multimedia interactive services as well as LAN/WAN data communication protocols, network architecture and communications standards for multimedia information transmission and retrieval. Conceptualize, analyze and prototype business related value added services, assessment of network architecture implications, and determination of network attributes required to support new services. An advanced degree, preferably a PhD in CS or EE with a concentration in data communications networks required. Working knowledge of C, C++, UNIX, network simulation tools, database management and network navigation tools is a plus. **Box ILU**

Cellular Radio Propagation Engineer

Responsibilities involve R&D in the area of radio propagation for cellular/personal communication systems operating at 800 and 1800 MHz, including developing models for predicting field strength and propagation systems; planning and executing measurement campaigns; as well as planning, engineering and optimizing cellular/personal communication systems using microcell propagation models. To qualify, candidates must have an MS/PhD in EE and 5-10 years' experience in propagation measurement and modeling for cellular and personal communication systems operating at 800 to 1800 MHz. The ability to plan cellular systems and model analog and digital communication systems highly desirable. **Box IJK-2**

We offer an outstanding benefits package, including an on-site fitness facility, medical/ life/dental insurance, pension, savings and investment plans. Please send your resume to the Employment Department, indicating appropriate Box Code, GTE Laboratories Incorporated, 40 Sylvan Road, Waltham, MA 02254. An equal opportunity employer, M/F/D/V.

GTE Laboratories

It's Amazing What We Can Do Together.™

recent books

Continued from p. 18T6

Walter H., AIP Press, New York, 1995, 623 pp., \$45.

Coherent Optical Communications Systems. Betti, Silvello, et al., John Wiley & Sons, New York, 1995, 539 pp., \$69.95.

In Marconi's Footsteps - Early Radio.

Jensen, Peter R., Kangaroo Press/Seven Hills Book Distributors, Cincinnati, Ohio, 1994, 176 pp., \$39.95.

Structured C for Engineering and Technology, 2nd edition. Adamson, Tom, et al., Prentice Hall, Englewood Cliffs, N.J., 1995, 713 pp., \$47.

Interactive SQL on the AS/400. Hovell, John F., Prentice Hall, Englewood Cliffs, N.J., 1995, 160 pp., \$35.

Integrated Circuit Quality and Reliability, 2nd edition. Hnatek, Eugene R., Marcel Dekker, New York, 1995, 808 pp., \$195.

Efficient C Programming: A Practical Approach. Weiss, Mark Allen, Prentice Hall, Englewood Cliffs, N.J., 1995, 529 pp., \$36.

Passive Optical Components for Optical Fiber Transmission. Kashima, Norio, Artech House, Norwood, Mass., 1995, 342 pp., \$85.

The Third Culture: Beyond the Scientific Revolution. Brockman, John, Prentice Hall, Englewood Cliffs, N.J., 1995, 432 pp., \$25.

Parallel Computing: Principles and Practice. Fountain, T. J., Cambridge University Press, New York, 1994, 346 pp., \$39.95.

Detection of Light: From the Ultraviolet to the Submillimeter. Rieke, G.H., Cambridge University Press, New York, 1994, 344 pp., \$59.95.

Industrial Ecology. Graedel, T.E., and Allenby, B.R., Prentice Hall, New York, Englewood Cliffs, N.J., 1995, 412 pp., \$37.

Rdb: A Comprehensive Guide, 2nd edition. Hobbs, Lilian, and England, Ken, Digital Press, Newton, Mass., 1995, 463 pp., \$39.95.

Network and Internetwork Security: Principles and Practice. Stallings, William, IEEE Press/Prentice Hall, Englewood Cliffs, N.J., 1995, 462 pp., \$55.

Implementing Concurrent Project Management. Turtle, Quentin C., Prentice Hall, Englewood Cliffs, N.J., 1994, 222 pp., \$45.

Strategic Alliances: An Entrepreneurial Approach to Globalization. Yoshino, Michael Y., and Rangan, U. Srinivasa, Harvard Business School Press, Boston, 1995, 272 pp., \$29.95.

Power Programming with Gupta SQLWindows. Lalwani, Rajesh, Prentice Hall, Englewood Cliffs, N.J., 1995, 328 pp., \$29.95.

Comprehensive Project Management: Integrating Optimization Models, Management Principles, and Computers. Badiru, Adedeji B., and Pulat, P. Simin, Prentice Hall, Englewood Cliffs, N.J., 1995, 548 pp., \$60.

Where Teamwork and Technical Excellence Provide CUSTOMER SOLUTIONS

The Communications Division of Analog Devices, a Fortune 500 Company, is recruiting a number of talented individuals to drive the organization to the forefront of the **Wireless, Telecom** and **Datacom** markets. As an example of intrapreneurship, where one benefits from the action and excitement of a start-up with the funding, resources, and stability of an \$800M company renowned for its engineering prowess and innovation, the Communications Division strives to create a robust and exhilarating environment offering challenge, recognition, and opportunity. Opportunities exist in the following disciplines and in various geographic locations including Wilmington, MA, Norwood, MA, and Portland, OR.

• CMOS VLSI

Digital & Mixed-Signal Design Engineers

• High Frequency

MMIC/RF IC Design Engineers

• RF and Digital

Product/Test Development Engineers

• RF, Hardware and Software

System Design Engineers

(GSM, DECT, CDMA, IS-54, ADSL, HFC)

Candidates with a minimum of 2 years experience in one or more of these areas who are interested in contributing to the quadrupling of the Communications Division's revenues over the next 4-5 years should send their resume, salary requirements, and geographic preferences to Attn: A.H. Shapiro, Ref: Spectrum, Analog Devices, 804 Woburn Street, Wilmington, MA 01887 Fax: 617-937-2009.

Analog Devices is an EEO/AA Employer M/F/H/V.



1 PRODUCT AND ADVERTISING INFORMATION

1	11	21	31	41	51	61	71	81	91	101	111	121	131	141	151	161	171	181	191	201	211	221	231
2	12	22	32	42	52	62	72	82	92	102	112	122	132	142	152	162	172	182	192	202	212	222	232
3	13	23	33	43	53	63	73	83	93	103	113	123	133	143	153	163	173	183	193	203	213	223	233
4	14	24	34	44	54	64	74	84	94	104	114	124	134	144	154	164	174	184	194	204	214	224	234
5	15	25	35	45	55	65	75	85	95	105	115	125	135	145	155	165	175	185	195	205	215	225	235
6	16	26	36	46	56	66	76	86	96	106	116	126	136	146	156	166	176	186	196	206	216	226	236
7	17	27	37	47	57	67	77	87	97	107	117	127	137	147	157	167	177	187	197	207	217	227	237
8	18	28	38	48	58	68	78	88	98	108	118	128	138	148	158	168	178	188	198	208	218	228	238
9	19	29	39	49	59	69	79	89	99	109	119	129	139	149	159	169	179	189	199	209	219	229	239
10	20	30	40	50	60	70	80	90	100	110	120	130	140	150	160	170	180	190	200	210	220	230	240

Print or Type only

Name _____ Title _____

Company _____

Address _____

City _____ State _____ Zip _____

Country _____ Business Phone _____

Send me information on joining IEEE (circle one): Regular membership 300 Student 301

2 ADDITIONAL COMMENTS

I would like: _____

Void after June 1, 1995 Void overseas after July 1, 1995 **3/95**

try Technical Conference (IA); May

e-mail, benb@synopsys.com.

801-220-2109; fax, 801-220-4895.

**Commercial Power
rence (IA);** May 8-11;
San Antonio, Texas;
622 Stoney Hill, San
3231; 210-671-4095.

**ference on Acoustics,
gnal Processing (SP);**
stin Hotel, Detroit; Al
ept., 4229 Engineering
f Michigan, Ann Arbor,
.763-0564; fax, -1503;
dip.eecs.umich.edu.

orks Workshop—IN
ay 9-11; Ottawa Con-
anada; Javan Erfanian,
B, 33 City Center Dr.,
N L5B 2N5, Canada;
fax, 905-615-8421;
omm.toronto.edu.

**Computer Applica-
nce (PE);** May 9-12;
vention Center, Salt
n; Robert Chisholm,
ver Supply, 168 N. 1950
City, UT 84115;
801-220-2109; fax, 801-220-4895.

WHERE TECHNICAL EXCELLENCE IS RECOGNIZED.

Electrical Engineers, Dayton, Ohio

Mission Research Corporation, a nationally respected high technology research company, seeks exceptionally talented and motivated engineers and programmers. Opportunities are available for electrical engineers with MS, PhDs or equivalent experience in the following areas:

- Radar design, analysis and Measurements
- Instrumentation Radar Operation
- Antennas and Radomes, with emphasis on Phased Arrays
- Indoor and Outdoor RCS Testing and Analysis
- IR/EO/Laser Analysis, Design and Measurements
- Warning Receivers and Processors
- EW/ECM Analysis and Testing
- Signal Processing

Please send resumes to: Mission Research Corp., Attn: Human Resources., P.O. Drawer 719, Santa Barbara, CA 93102. MRC is an EEO/AA employer. Applicants must be eligible for a security clearance.

Mission Research Corporation



recent

Continued from p. 18T6

Walter H., AIP Press
623 pp., \$45.

**Coherent Optical C
Systems.** Betti, Silvello,
Sons, New York, 199

In Marconi's Footste

W
Techni
CUST

The Communications

■ number of talented in

Telecom and Datacon

the action and excitement of ■ start-up with the funding, resources, and stability of an \$800M company renowned for its engineering prowess and innovation, the Communications Division strives to create a robust and exhilarating environment offering challenge, recognition, and opportunity. Opportunities exist in the following disciplines and in various geographic locations including Wilmington, MA, Norwood, MA, and Portland, OR.

• CMOS VLSI

Digital & Mixed-Signal Design Engineers

• High Frequency

MMIC/RF IC Design Engineers

• RF and Digital

Product/Test Development Engineers

• RF, Hardware and Software

System Design Engineers

(GSM, DECT, CDMA, IS-54, ADSL, HFC)

Candidates with a minimum of 2 years experience in one or more of these areas who are interested in contributing to the quadrupling of the Communications Division's revenues over the next 4-5 years should send their resume, salary requirements, and geographic preferences to **Attn: A.H. Shapiro, Ref: Spectrum, Analog Devices, 804 Woburn Street, Wilmington, MA 01887 Fax: 617-937-2009.**

Analog Devices is an EEO/AA Employer M/F/H/V.



BUSINESS REPLY MAIL

FIRST CLASS MAIL PERMIT NO. 885, PITTSFIELD, MA

POSTAGE WILL BE PAID BY ADDRESSEE



READER SERVICE MANAGEMENT DEPT

PO BOX 5149

PITTSFIELD MA 01203-9740

NO POSTAGE
NECESSARY
IF MAILED
IN THE
UNITED STATES

York, 1994, 344 pp., \$59.95.

Industrial Ecology. Graedel, T.E., and Allenby, B.R., Prentice Hall, New York, Englewood Cliffs, N.J., 1995, 412 pp., \$37.

Rdb: A Comprehensive Guide, 2nd edition. Hobbs, Lilian, and England, Ken, Digital Press, Newton, Mass., 1995, 463 pp., \$39.95.

Network and Internetwork Security: Principles and Practice. Stallings, William, IEEE Press/Prentice Hall, Englewood Cliffs, N.J., 1995, 462 pp., \$55.

Implementing Concurrent Project Management. Turtle, Quentin C., Prentice Hall, Englewood Cliffs, N.J., 1994, 222 pp., \$45.

Strategic Alliances: An Entrepreneurial Approach to Globalization. Yoshino, Michael Y., and Rangan, U. Srinivasa, Harvard Business School Press, Boston, 1995, 272 pp., \$29.95.

Power Programming with Gupta SQLWindows. Lalwani, Rajesh, Prentice Hall, Englewood Cliffs, N.J., 1995, 328 pp., \$29.95.

Comprehensive Project Management: Integrating Optimization Models, Management Principles, and Computers. Badiru, Adediji B., and Pulat, P. Simin, Prentice Hall, Englewood Cliffs, N.J., 1995, 548 pp., \$60.

Continued from p. 16E8

Custom Integrated Circuits Conference—CICC '95 (ED, SSC); May 1-4; Westin Hotel, Santa Clara, Calif.; Melissa Widerkehr, Widerkehr and Associates, Suite 610, 1545 18th St., N.W., Washington, DC 20036; 202-986-2166; fax, 202-986-1139.

Fourth International Symposium on Integrated Network Management—Isinm '95 (COM); May 1-5; Red Lion Hotel, Santa Barbara, Calif.; M. Olson, Isinm '95, Box 22605, Santa Barbara, CA 93101; 805-569-1222; fax, -2227; e-mail, isinm@cs.ucsb.edu.

Particle Accelerator Conference (NPS); May 1-5; Hyatt Regency, Dallas; B. Montoya, Los Alamos National Lab, Box 1663, MS H850, Los Alamos, NM 87545; 505-667-5634; fax, -665-8604; e-mail, Beckym@lanl.gov.

Annual Textile, Fiber and Film Industry Technical Conference (IA); May

2-4; Hyatt Regency, Charlotte, N.C.; Robert D. Henderson, RDH Consultants Inc., Box 7264, Charlotte, NC 28241; 704-588-6538.

Fifth Workshop on Hot Topics in Operating Systems (C); May 4-5; Rosario Resort, Orcas Island, Wash.; Michael Jones, Microsoft Corp., One Microsoft Way, Building 9S/1047, Redmond, WA 98052; 206-936-8846; fax, 206-936-7329; e-mail, mbj@microsoft.com.

International Radar Conference (AES, NCAC); May 7-11; Radisson Mark Plaza Hotel, Alexandria, Va.; Tom Fagan, IEEE International Radar Conference, 1000 Wilson Blvd., 30th Floor, Arlington, VA 22209; 703-247-2988; fax, 703-276-9706.

Second International Test Synthesis Workshop (C); May 8-10; Red Lion Resort, Santa Barbara, Calif.; Ben Ben-netts, Synopsys, 700 East Middlefield Rd., Mountain View, CA 94043; 415-694-4244; fax, 415-694-4128; e-mail, benb@synopsys.com.

Industrial and Commercial Power System Conference (IA); May 8-11; Menger Hotel, San Antonio, Texas; M. Osborn, 13622 Stoney Hill, San Antonio, TX 78231; 210-671-4095.

International Conference on Acoustics, Speech and Signal Processing (SP); May 8-12; Westin Hotel, Detroit; Al Hero, EECS Dept., 4229 Engineering 1, University of Michigan, Ann Arbor, MI 48109; 313-763-0564; fax, -1503; e-mail, hero@di.eecs.umich.edu.

Intelligent Networks Workshop—IN '95 (COM); May 9-11; Ottawa Congress Center, Canada; Javan Erfanian, Stantor, Floor 6B, 33 City Center Dr., Mississauga, ON L5B 2N5, Canada; 905-615-6486; fax, 905-615-8421; e-mail, javan@comm.toronto.edu.

Power Industry Computer Applications Conference (PE); May 9-12; Salt Palace Convention Center, Salt Lake City, Utah; Robert Chisholm, PacifiCorp. Power Supply, 168 N. 1950 West, Salt Lake City, UT 84115; 801-220-2109; fax, 801-220-4895.

WHERE TECHNICAL EXCELLENCE IS RECOGNIZED.

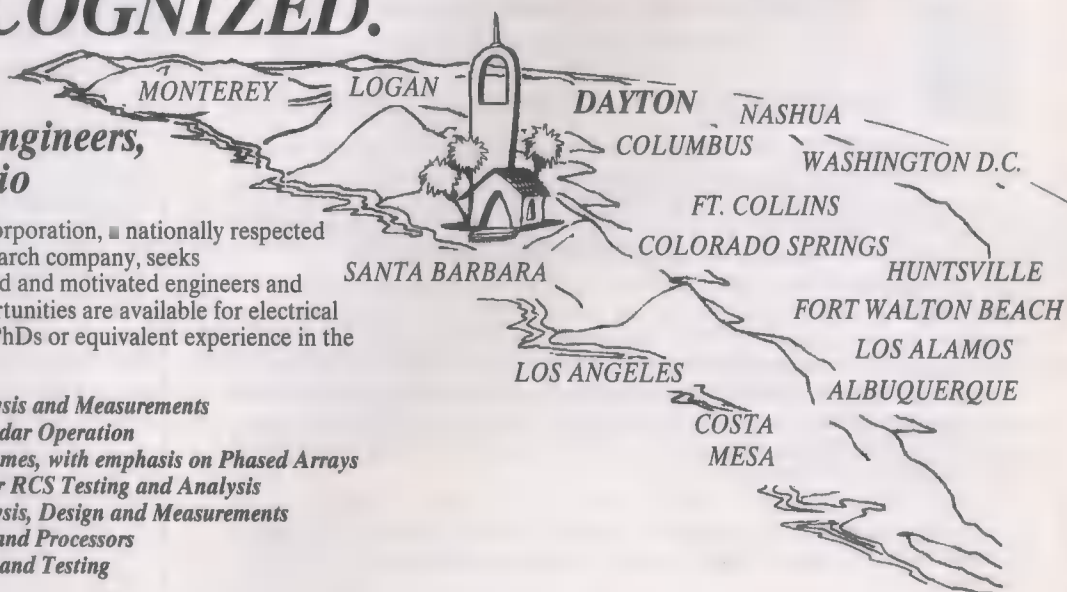
Electrical Engineers, Dayton, Ohio

Mission Research Corporation, a nationally respected high technology research company, seeks exceptionally talented and motivated engineers and programmers. Opportunities are available for electrical engineers with MS, PhDs or equivalent experience in the following areas:

- Radar design, analysis and Measurements
- Instrumentation Radar Operation
- Antennas and Radomes, with emphasis on Phased Arrays
- Indoor and Outdoor RCS Testing and Analysis
- IR/EO/Laser Analysis, Design and Measurements
- Warning Receivers and Processors
- EW/ECM Analysis and Testing
- Signal Processing

Please send resumes to: Mission Research Corp., Attn: Human Resources, P.O. Drawer 719, Santa Barbara, CA 93102. MRC is an EEO/AA employer. Applicants must be eligible for a security clearance.

Mission Research Corporation



Consumers Power Company, Michigan's largest electric and gas utility and the principal subsidiary of CMS Energy Corporation, has an immediate opportunity for the following position:

Radio Engineer

Calling upon your BSEE and years of experience with radio network design, communications equipment and software, you will provide engineering support for the following areas: **development of system standards, performance levels, system design, equipment specification and acquisition, contract negotiations, installation conformance verification, extensive end user interaction, technical support of RF technology, technical training and systems documentation.**

Qualified candidates will have experience in radio and communications engineering and systems integration. Other required areas of expertise include: **trunked 800Mhz, mobile radio systems, remote monitoring systems, mobile data applications, radio dispatch systems, digital and analog microwave systems, peripheral equipment and subsystems.** Special emphasis is placed on the ability to communicate and plan project implementation activities; coordinate the activities and priorities of vendors, contractors, and consultants during project activities; and assist team members on complex projects.

We offer a competitive salary and comprehensive benefit package, as well as a professional work environment. For confidential consideration, send your resume and salary expectations to: **Professional Staffing, 010-95; Consumers Power Company; 212 W. Michigan Avenue; Jackson, MI 49201.**

An Equal Opportunity/Affirmative Action Employer



**Consumers
Power**

**POWERING
MICHIGAN'S PROGRESS**

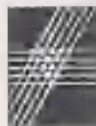
WESTIN

ENGINEERS AND SYSTEMS ANALYSTS INFORMATION,
CONTROL AND TELECOMMUNICATION SYSTEMS

Westin Engineering, Inc. a leading consulting firm in the design of information, control and telecommunication systems for Water/ Wastewater, Gas, Oil and Electric utilities, seeks qualified management consultants, engineers and analysts for major new projects. Minimum requirements include B.S. degree in engineering or computer science and 10 years experience in systems design or implementation. Our employee-owned firm offers excellent salaries, a comprehensive benefits package, and an Employee Stock Ownership Program (ESOP). Westin has offices worldwide and continues to experience steady growth. E.O.E.

Send your resume in confidence to: Barbara Wylie

Westin Engineering, Inc.
100 Park Center Plaza
Suite 500
San Jose, CA 95113



The Beckman Institute for Advanced Science and Technology

University of Illinois at Urbana-Champaign

ASSOCIATE DIRECTOR FOR EXTERNAL AFFAIRS AND RESEARCH

The Beckman Institute for Advanced Science and Technology at the University of Illinois at Urbana-Champaign (UIUC) is the nation's largest, most broadly based multidisciplinary academic research organization, housing more than 700 researchers in areas ranging from biological intelligence and human-computer intelligent interaction, to molecular and electronic nanostructures. The 84 research faculty are drawn from 16 departments at UIUC.

The Beckman Institute seeks ■ experienced manager or executive, from government, academia, or industry, with the necessary scientific stature to work with corporate executives, government officials, and academic and industrial research scientists, to develop broad-scale research relationships between the Institute and entities such as corporations, research institutes, and government agencies. These relations include major multidisciplinary research projects involving researchers from academia, industry, national laboratories, and industrial laboratories. The Associate Director will also assist the Director in the daily operation of specialized research facilities and coordinate public relations efforts.

The position is a regular full-time academic professional appointment. An earned doctorate in ■ engineering or science discipline is strongly preferred, but the combination of an advanced degree in science or engineering and appropriate industrial experience will be considered.

The position begins August 21, 1995, and all applications received by May 1, 1995 will receive full consideration, though applications may be accepted until the position is filled. Please send ■ letter of interest, resumé, and names and contact information for at least three references to:

Jiri Jonas, Director

Beckman Institute for Advanced Science and Technology
University of Illinois ■ Urbana-Champaign
■ North Mathews Avenue, Urbana, IL 61801
j-jonas@uiuc.edu, 217-244-1176.

The University of Illinois is ■ AA/EEO Employer.

Engineering

RF Power Products, Inc., a leading supplier of RF delivery systems from 50 kHz to 100 MHz, with power levels up to 25,000 watts has the following openings. These positions are staff expansions to meet the increasing demands of RFPP's continued growth.

RF ENGINEERS - Design engineers to develop RF power systems consisting of power generators and/or matching networks to meet customer specifications. Working knowledge of RF required. Minimum BSEE, MSEE preferred, and/or 10 years RF related industrial experience. Candidates must be experienced in CAD and have strong communication skills.

RF CUSTOMER SERVICE ENGINEER - To interface directly with customers in various matters relating to our products and applications. BSEE plus several years experience in RF power systems required. Initially requires relocation to Korea/Japan.

RF APPLICATIONS ENGINEER - To work in San Jose office interacting with sales, engineering, and customers in developing RF technology for current and future projects. BS plus 5 yrs, or 10-12 yrs directly related industry experience required. Some travel necessary.

RF Power Products, Inc. offers excellent career opportunities, competitive salaries, comprehensive benefits, and relocation package. Respond in confidence to PO Box 490, Marlton, NJ 08053, fax 609-751-2143. EOE.



ACCEPT THE NAVY CHALLENGE

Become a member of an elite research and development community under the Chief of Naval Research involved in basic and applied scientific research and advanced technological development for tomorrow's Navy.

Listed below are career opportunities* for Senior Managers of a variety of broad research programs in theoretical research and experimental fields:

- **Director, Electronics Division, Office of Naval Research (ID#95-04)**
Manages and directs extensive activities in fostering, administering, and executing an integrated program of basic research, exploratory development, and advanced technology development in the field of electronics and related areas. Duty station: Office of Naval Research, Arlington, VA. Contact: Ms. Jill Blackwell, (703) 696-4653.
- **Director, Mechanics and Energy Conversion S&T Division, Office of Naval Research (ID#95-05)**
Manages and directs an integrated program of basic research, exploratory development, and advanced technology development in the fields of fluid dynamics (aero- and hydromechanics), fluid structure interaction, energetic materials, propulsion processes, and weapons technology. Duty station: Office of Naval Research, Arlington, VA. Contact: Ms. Roberta Perry, (703) 696-4587.
- **Director, Ship Structures and Systems S&T Division, Office of Naval Research (ID#95-06)**
Manages and directs a program of basic research, exploratory development, and advanced technology development in the fields of solid mechanics, electromechanics, fracture mechanics, structural dynamics, structural acoustics, electric power, ship structures, ship and marine acoustic and non-acoustic signature technology, propulsion technology and system integration. Duty station: Office of Naval Research, Arlington, VA. Contact: Ms. Roberta Perry, (703) 696-4587.
- **Director, Ocean, Atmosphere, and Space (OAS) Modeling and Prediction Division, Office of Naval Research (ID#95-07)**
Manages and directs extensive activities in fostering, administering, and executing an integrated program of basic research, exploratory development, and advanced technology development in the wide range of interdisciplinary fields included in the Division such as environmental optics; physical oceanography; biological/chemical oceanography; ocean modeling and prediction; atmospheric modeling and prediction; high latitude dynamics; tactical environmental support; and marine geology, geophysics and meteorology. Duty station: Office of Naval Research, Arlington, VA. Contact: Ms. Angelica Ashby, (703) 696-4649.
- **Superintendent, Remote Sensing Division, Naval Research Laboratory (ID#95-01)**
Plans and directs a program of research, development, and evaluation leading to the creating, adoption and application of improved and new concepts, principles, methods, and techniques in the fields of remote sensing, sensor technology, atmospheric sciences, oceanography, astronomy, and terrestrial sciences. Duty station: Naval Research Laboratory, Washington, DC. Contact: Ms. Kathy Weaver, (202) 767-3030.
- **Superintendent, Spacecraft Engineering Department, Naval Research Laboratory (ID#95-02)**
Responsible for the conception, planning and formulation of research, design and development in the areas of satellite and orbital transfer vehicle systems. Duty station: Naval Research Laboratory, Washington, DC. Contact: Ms. Patricia Reed (202) 767-3030.
- **Superintendent, Marine Meteorology Division, Naval Research Laboratory (ID#95-03)**
Manages, directs and administers a broad spectrum of multi-disciplinary scientific, engineering, and technical programs in numerical weather forecasting; atmospheric physics, processes and phenomena; ocean atmospheric coupling; satellite meteorology; data base management and visual information systems; and automation techniques for atmospheric analysis forecasting. Duty station: Naval Research Laboratory, Monterey, CA. Contact: Ms. Mary Branick, (202) 767-3030.

Apply to:
HRO-DC Attn: (ID#)IS
Naval Research Laboratory
4555 Overlook Avenue SW
Washington DC 20375-5320

Applicants should be recognized as national/international authorities in their specialty and should have planned and executed difficult programs of national significance or specialized programs that show outstanding attainments in their field of research or consultation. Salaries range from \$92,900 to \$115,700 (plus locality pay) per year. Resumes, SF-171s (Application for Federal Employment) or OF-612s (Optional Application for Federal Employment) must be received by 31 March 1995.

*Each position will be filled subject to position allocation availability.

Navy is an Equal Opportunity Employer
(Women and Minorities are encouraged to apply)

MANAGER POWER OPERATIONS

Martin Marietta Utility Services (MMUS), a subcontractor to the United States Enrichment Corporation (USEC), is seeking a highly motivated professional to join its Portsmouth, Ohio, Gaseous Diffusion Plant. This is one of two plants operated by MMUS which produces commercial grade enriched uranium for use in nuclear power plant reactors world wide. This position is responsible for providing strong leadership, planning and direction for the operation and maintenance of a high voltage transmission and distribution system in an industrial plant environment with a design capacity of 2260 MW's. Major responsibilities encompass providing executive, administrative, and technical direction to the Power Department to ensure a safe, efficient, reliable operation by maintaining the electrical system at the highest level of integrity with emphasis on safety, environmental, training, cost control, and quality assurance. This position is the principal contact with the power supplier and USEC on power contract matters and other related technical matters involving the electrical power system. This position manages the activities of 65 to 70 employees (45 to 50 hourly) and an annual operating and power budget of \$270 million dollars.

Requires as a minimum a B.S. degree in Electrical Engineering with a major in Power plus 10 years of experience in the operation and maintenance of a high voltage power transmission and distribution system with at least 5 years management experience of such a system. Must be knowledgeable of heavy industrial plant operations, processes and facilities and ANSI/IEEE/NEC/NESC/OSHA Codes and Standards for Electrical Safety. Requires effective communication, supervisory and management skills and ability to administer Company/Union contract. The applicant must physically be capable to oversee, monitor and perform field inspections on electrical equipment and jobs anywhere on plantsite. A Professional Engineering (PE) license is desired. Must be a U.S. citizen and be able to obtain a government security clearance.

Please send your confidential replies to:
MARTIN MARIETTA UTILITY SERVICES, INC.
Attn: Employment Department, MS-1131
P.O. Box 628
Piketon, OH 45661

MARTIN MARIETTA

MARTIN MARIETTA UTILITY SERVICES, INC.

Technical Professionals

Sprint, a leader in the telecommunications industry, is seeking technical professionals. The ideal candidates are hands-on, results-oriented R&D engineers with a vision of how to apply emerging technologies to create network-based innovative future services.

These positions require strong technical backgrounds (BS/MS in EE or CS) with 5+ years experience in developing software/hardware systems in the telecommunications/information industry. While having strong individual contributor skills, these candidates must evolve in a small, highly skilled team environment, requiring a wide breadth of knowledge in software systems and communications. Experience in more than one of the following areas is desirable: client server, multiplatform, wireless, virtual reality, speech recognition and system architectures. The individuals must be innovative and visionary and must have strong interpersonal skills to be able to communicate effectively with senior management.

We offer an excellent compensation and benefits package in an exciting environment. For consideration, please send a resume to: **Staffing Department, Dept. LF/CCS, P.O. Box 12915, Shawnee Mission, KS 66272-2915.** We are proud to be an EEO/AA employer M/F/D/V. Also, we maintain a drug-free workplace and perform pre-employment substance abuse testing.



The Memphis Collaboration for Biomedical Engineering (BME)

A Special Opportunity Award from The Whitaker Foundation will allow the University of Tennessee, Memphis [UT Memphis] and the University of Memphis [U Memphis] individually to add faculty and to develop further their joint curriculum in BME. This collaboration draws upon substantial resources in Memphis: four major universities, several teaching hospitals in a major medical center, including the nationally known St. Jude Children's Research Hospital, and three major implant manufacturers.

Both universities seek individuals with excellent capacity for teaching and research; candidates should present obvious potential to build a solid research program based on externally funded support. The positions described below are in tenure tracks and require an earned doctorate in engineering or a closely related field; post-doctoral experience is desirable. At each university, screening of applications will begin March 15, 1995 and continue until each position is filled.

Faculty Position At U Memphis:

Candidates at the assistant or associate professor level are being sought who have a demonstrated expertise in experimental and/or simulation of electrocardiology. Applications from persons with unusually strong credentials in other electrically oriented aspects of BME are also encouraged. Applicants should send a Curriculum Vitae, a summary of their research plans, and names of three references to: Dr. Fritz Claydon, Chair of Search Committee, Department of Biomedical Engineering, The University of Memphis, Memphis, TN 38152, e-mail: fclaydon@adm1.memphis.edu, phone: 901-678-2171

An Equal Opportunity/Affirmative Action Institution / The Successful Candidate Must Meet Immigration Reform Act Criteria

Faculty Position At UT Memphis:

Candidates at the assistant professor level are being sought in two areas: (a) computer-oriented BME, particularly high performance distributed computing and clinical support or (b) biomechanical engineering, especially physiological fluid flow, tissue engineering, and implantable devices. Persons in other areas of BME who have particularly strong credentials will be considered. Applicants should send a Curriculum Vitae, a summary of their research plans, the names of three references to: Dr. E. Eckstein, Com. Chair, BME, UT Memphis, 500 Madison Ave., Suite 801, Memphis, TN 38163, e-mail: eeckstein@bme.utmem.edu, phone: 901-448-7099

The University of Tennessee is an Equal Opportunity/Affirmative Action/Title IX/Section 504/ADA Employer

COMMUNICATION SYSTEMS & SOFTWARE PROFESSIONALS (Entry to Senior Level)

The Network Technology Division of COMSAT Laboratories is seeking individuals with backgrounds in advanced communications systems. Qualified candidates will have an opportunity to participate in research and development projects in the following areas:

- Mobile and fixed satellite and terrestrial communication systems
- PCS and cellular systems (GSM, INMARSAT P-21)
- Wireless local loop systems
- ATM, frame relay, ISDN and SS#7 networking
- High speed data networks
- Time-division-multiple-access (TDMA)

You must have a MS or PhD in Electrical Engineering, Computer Science, or related field, and experience in one or more of the following areas: telecommunications systems software development; PCS/cellular systems and technology; and the ability to perform analysis, modeling, and simulation.

COMSAT offers competitive salaries and a flexible benefits plan that you can design to meet your personal/family needs. To apply, send your resume and salary history to: **COMSAT Laboratories, Attn: IEEE, 22300 Comsat Drive, Clarksburg, MD 20871.** EOE M/F/D/V.



Creating High-Frequency Design Solutions

When you combine a cutting-edge technical environment with challenge, growth, and a choice of spectacular locations, you'll find HP EEsof. As an industry leader developing high-frequency software solutions for engineers worldwide, HP EEsof continues to deliver the latest technology in powerful simulation and modeling tools. And, our division offers the advantage of having two diverse locations - each offering an attractive lifestyle to balance your career.

Situated in the rolling green countryside of Sonoma County, **Santa Rosa** is a perfect blend of country living with big city activities close-by. Just 50 miles north of San Francisco in the wine country, Santa Rosa is a thriving community with easy commutes and a diverse blend of cultural, sports and recreational activities available.

Located in the hills between Santa Barbara and Los Angeles, **Westlake Village** is ideally situated for visiting the nearby Pacific Ocean, hiking in the Santa Monica Mountains, snow skiing on nearby slopes, or enjoying a multitude of local cultural activities.

If you are interested in working with individuals focused on customer needs through a blending of expertise, advanced technologies and products, consider the following openings:

Product Development Engineers

Openings are available in the following software design areas and require a BS/MS in EE or CS or equivalent, with at least 2 years' related experience, C programming skills, and proficiency in software design methodology. The ability to communicate effectively is also needed as these positions involve customer visits, market-focused product definition, and maintenance of existing products and technical support.

- Use your software engineering expertise to create high-frequency electrical CAD/CAE tools for design entry, simulation control, interprocess communication and physical design. In addition, you will design, implement, test and document commercial CAE software and cross-platform development for UNIX® and PCs running 32-bit Windows*.
- Design and develop software programs, measurement and extraction algorithms and hardware design to support a modeling system for both active and passive device characterization. Requires knowledge of network analyzer measurements and associated calibration techniques.
- Participate in the design and development of RF/MW synthesis tools including integration into design environments. Experience with RF/MW simulators desirable. Requires knowledge of synthesis or RF/MW design experience.
- Join in creating software tools used in the physical design of high-frequency circuits, including RF integrated circuit, microwave integrated circuit, hybrid circuit, and circuit board design. Understanding of algorithms and data structures used in layout programs a must.

- Contribute to the development of software designed to model high-speed interconnects, ground and power planes, and bus drivers. Models will be used to characterize the impairment of high-speed digital signals resulting from these structures. Requires familiarity with digital design techniques, logic simulation, and analog simulators such as SPICE.
- Join the design team focusing on the development of high-frequency communication system simulation products. Requires a firm foundation in relating communication system theory to hardware requirements and performance. Desirable to have knowledge of GSM, TDMA or CDMA wireless systems.

Product Marketing Engineers

Research markets, participate in the definition of new products and design marketing programs that promote new products. In addition, you will participate in technical seminars, trade shows, and sales support. Requires a BSEE, knowledge of high-frequency design and good verbal and written communication skills. Specific openings are available in the following areas:

- Products for Windows, Windows 95, and Windows N/T
- Design Environment and EDA Interfaces
- System Simulation and Design Automation

Technical Support Engineer

Provide customer support via telephone, e-mail and written correspondence for the product areas of circuit simulation and layout. In addition, document customer support issues in call tracking database and communicate customer feedback to R&D via defect reports and enhancement requests. You will also evaluate products prior to production release, create and revise training manuals and conduct customer training classes. Requires a BSEE with at least 2 years' nonlinear microwave or RF circuit design experience. A working knowledge of high-frequency test equipment, nonlinear device modeling, UNIX and excellent communications skills are required.

In addition to a broad benefits package, relocation support will be provided. To apply for HP EEsof openings, please send your resume to: **Hewlett-Packard Employment Response Center, Attn: Ad#1238, 3000 Hanover Street, MS 20AZ, Palo Alto, CA 94304-1181.** You may also send your ASCII text resume to: hpresume@hpcc14.corp.hp.com Hewlett-Packard Company is an equal opportunity employer dedicated to affirmative action and work force diversity.

UNIX is a registered trademark in the U.S. and other countries, licensed exclusively through X/Open™ Company Limited. X/Open is a trademark of X/Open Company Limited in the U.K. and other countries. Windows is a U.S. trademark of Microsoft Corp.



**HEWLETT®
PACKARD**



The Future Belongs To Those Who
Can Go Beyond The Obvious.

R&D Engineers

Digital Video

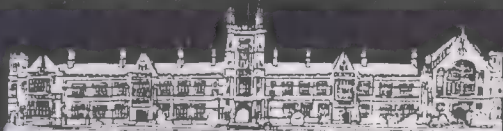
Hardware Development (BSEE/MSEE)
Software Engineering (BS/MS EE or CS)
ASIC Design (BSEE/MSEE)

THOMSON CONSUMER ELECTRONICS
Indianapolis, Indiana

RCA, GE and ProScan brand consumer electronics.

We rely on diversity to fuel innovation. EOE. M/F/D/V.

Fax 317.587.6762 • lovell@tccmail.indy.tce.com



The University of Sydney
AUSTRALIA

Faculty of Engineering

LECTURER

Department of Electrical Engineering
(Fixed Term or Tenurable)

Reference No: B01/03

The department is looking to expand its research and advanced teaching capability in the electrical Systems area. In line with a strategic plan which emphasises postgraduate studies an appointee with an understanding research career potential is sought. The position arises from the appointment to the Chair of Electrical Engineering of Professor David Hill. The existing staff in related areas have research interests in nonlinear and adaptive control, power systems, electrical vehicles, power electronic circuits, multidimensional systems, neural networks, artificial intelligence, communications systems, image processing, plasma engineering and optical fibre sensing. Generally, the department is vigorously developing its research work to the highest international standards. A special feature of this effect is the high level of interaction with industry, both local and international.

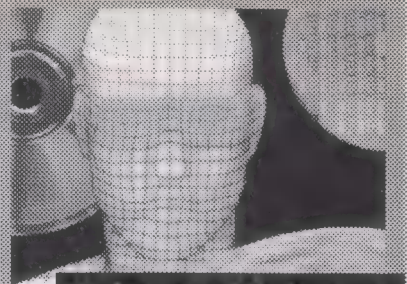
The appointee must have completed a PhD with a high level of research outcomes, have the capability to supervise research students and present advanced courses. Undergraduate teaching experience and experience of industrial applications are desirable. Preference will be given to applicants with analytical skills in the systems area, i.e. stability analysis, optimisation, synthesis, computational techniques and related subjects.

The position may be offered as a 5-year fixed term appointment or, for exceptional applicant, be offered as Tenurable appointment. Membership of a University approved superannuation scheme is a condition of employment for new appointees. For further information contact Professor David J. Hill on (61 2) 351 4647, fax: (61 2) 351 3847, email: davidh@ee.su.oz.au or the Head of Department, Professor Trevor Cole on (61 2) 351 2682, fax: (61 2) 351 3847, email: trevor@ee.su.oz.au.

Salary: Level B \$A42,198 - \$A50,111 p.a. Closing: 17 March 1995

Method of Application: Three copies of the application, quoting and Reference No, including curriculum vitae, list of publications and the names, addresses and fax numbers of at least three and not more than five referees to The Personnel Officer, (Group B), Link Building, (J13), The University of Sydney, NSW, Australia 2006.

Equal opportunity monitoring and no discrimination in the workplace are University policies. The University reserves the right not to proceed with an appointment for financial or other reasons.



Spheres of Influence

You'll see more chances to make a real impact at **Philips Semiconductors**. With major new development efforts in some of the most exciting areas of integrated circuits. And the technology resources of one of the largest privately funded research organizations in the world. In the **Albuquerque operation**, there are a variety of positions for advanced technology BiCMOS process integration

Senior Tech Staff Member

Develop and integrate high performance BiCMOS technologies using your in-depth knowledge of IC wafer fab process modules and IC manufacturing. You should have at least an MS (Ph.D. preferred) in solid state Physics or Electrical Engineering with 3 years of relevant experience and skill in process simulation tools SUPREM3, SUPREM4.

Advanced Technology Development Specialist

Work on cross-functional teams as an inter-connect engineer for vertical process integration with Technology Development. You will design and implement Fab experiments, monitor experiments in progress, and complete data analysis and generation of final technical reports. A Masters degree or equivalent in engineering or science and an in-depth understanding of backend processing including photo, etch, and thin films is required. Excellent written and verbal communication skills are necessary.

BiCMOS Device Engineer This is a Sunnyvale, CA position

Use your strong background in solid-state device physics, understanding of CMOS and bipolar device operation, and ability to perform device characterization measurements in this entry-level position. You will collect and analyze data, and generate reports as part of the development of an NVM element integration into advanced BiCMOS technology. A BS/MS in solid state Physics with 1-2 years experience is required. Experience with HP4145SPA and process simulation is desirable.

We offer competitive compensation and a comprehensive benefits package.

Please send your resume to: **Philips Semiconductors**, Professional Staffing, 9201 Pan American Fwy. NE, Albuquerque, NM 87113 or FAX to (505) 822-7494. As a division of Philips Electronics North America Corporation, we believe in maintaining a safe work environment for all employees and require pre-employment drug and alcohol testing. EOE. Principals only. No phone calls, please.



PHILIPS



We've set a new goal for ourselves.

At Motorola Semiconductor Products Sector (SPS), excellence is simply not enough. We've already earned the enviable position of America's predominant semiconductor company. But now, we've set our sights even higher: we plan to become the best business in the business, anywhere.

We are achieving this goal by operating the world's most advanced manufacturing facilities. Consider our new, state-of-the-art 8" wafer fab operation in Chandler, AZ and our newest wafer fab facility (COM1) in Phoenix, AZ. In Texas, we are building a billion dollar ULSI/MOS 13 factory which will house both a CMOS microelectronics R&D center and a high volume, next generation manufacturing facility. If you seek an environment where state-of-the-art is defined, SPS is the best place to make your move.

Within Motorola, you'll find unprecedented growth, exceptional financial performance, and a sense of dedication and determination to hit the mark higher than anyone has before, as we design, manufacture and market many of the industry's most advanced chips. This separates our opportunities from any other. Make your move to Motorola. Openings exist at the following facilities:

Phoenix, AZ

Wafer Process Technicians — Requires experience in diffusion, metrology, photolithography, etch, etc.

Equipment/Maintenance Technicians — Requires experience in maintenance and/or process sustaining in wafer manufacturing in the areas of photolithography, metrology, wafer, polishing, thin films, diffusion, etch, vacuum, probe, implant, metals and background.

Manufacturing Supervisors — Meet goals for wafer fab productivity, process yields, inventory control, equipment and personnel development.

Device Engineers — Facilitate quality, reliability, yield and process development for advanced CMOS and BiCMOS processes. Requires 3 years in fab process/device engineering. Knowledge of BiCMOS or Bipolar device physics must.

Device Technicians — Requires a minimum of 3 years fab device/process sustaining experience.

Circuit Designers — Design complex CMOS circuitry for memory, microprocessor and PowerPC devices. Requires ability to perform circuit analysis, verification and design for test.

Circuit Design Engineers — Design of analog and mixed-mode CMOS sensor/signal processing ICs. Familiarity with CAD tools required.

Sr. FSRAM Applications Engineers — As lead consultant in new product development, you will provide customer support/training, develop technical documentation and troubleshoot.

Sr. Product Engineer for Flash Memory — Strong technical skills are essential as we start-up assembly/test manufacturing and perform qualification testing on this new product line. A thorough knowledge of flash memory final testing, reliability testing and qualification procedures is essential.

Technical Support Specialist — Provide critical UNIX and SUN/HP technical support at multiple sites. Excellent leadership and project management skills are essential.

CIM/Systems Engineers — Perform distributed manufacturing applications, integration, development and support. Requires knowledge of Oracle, CASE, SAS, UNIX and C.

Process/Device/Equipment Engineers — Photo, etch, diffusion and implant experience required. Special need for Engineer with C4/polymide background.

For positions in Phoenix, FAX resumes to (602) 921-4386, or mail resumes to: Motorola SPS Sourcing, Dept. SPS-513, 1438 W. Broadway Rd., Suite B100, Tempe, AZ 85282.

Austin, TX

Process Engineers — Requires wafer processing experience, proven expertise in application of SPC and design of experiments, as well as a working knowledge of photo, etch, thin film, implant or diffusion processes.

Equipment Engineers — Evaluate, install and modify wafer processing equipment. Requires working knowledge in one of the following disciplines: photo, wet/dry etch, diffusion, HIVEC or EPI.

Circuit Designers — Requires experience in CMOS microprocessors or memory components circuit design. Familiarity with basic circuit design techniques, pre-charge/evaluate, self-timed logic, as well as layout and characterization required. Familiarity with schematics and layout editors preferred.

Circuit Designers — CMOS VLSI logic and circuit design with experience in low-power designs, logic synthesis, Verilog, and some Analog. Knowledge of system level design is required.

CAE — Develop integrated VLSI CAD platforms based on vendor tools and design/code. Includes design methodology and tool support. Experience in workstation tool development and software integration essential.

Chip Verification Engineer — Develop verification programs/behaviorals for high performance microprocessor functions, as well as perform failure analysis at chip levels and driving functional simulation. Must have C and UNIX experience with knowledge of high performance architectures.

QA/Reliability Engineer — Support reliability testing and failure analysis. Must possess skills in memory/microprocessor devices, wafer fabrication knowledge, MOS device physics, test software and DOE.

Design for Test Engineer — Requires experience in design and test of high density and high performance custom CMOS devices. Background in LSSD, scan-set design, JTAG and other DFT techniques essential.

Product Engineers — Will ensure effective microprocessor product yield/cost management for Power PC, memory and microprocessor devices. Involves interfacing with customers and characterizing products. Assembly and final test background preferred.

For positions in Austin, call (800) 531-5183, or send resume to: Motorola SPS Sourcing, Dept. ATX-9507, 5835 Barton Springs Rd., One Texas Center, Suite 400, Austin, TX 78704. Internet: spsjobs@email.mot.com.

All resumes are electronically OCR scanned, processed and distributed. A letter quality resume with a standard typeface is required (no underlines or bold, please). An Equal Opportunity/Affirmative Action Employer. We Welcome And Encourage Diversity In Our Workplace.



MOTOROLA

Semiconductor Products Sector

SciTech

SOFTWARE *Best Sellers* FOR SCIENCE[®] at great prices!

call 1-800-622-3345

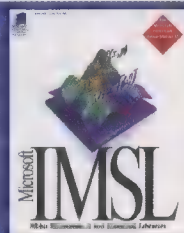


MICROSOFT[®] FORTRAN POWERSTATION

Develop & run Fortran programs of virtually any size ■ complexity with Microsoft FORTRAN PowerStation family of 32-bit development systems! Migrate Fortran code from other platforms with little or no modification! Get unparalleled price/performance!

Save time in code development and maintenance using the Windows integrated development environment. Call NOW to order or request a FREE Test Drive Kit!

DOS & Windows price\$339
Windows NT price\$519



MICROSOFT[®] IMSL[®] MATH & STATS LIBRARIES

Complement Microsoft FORTRAN PowerStation with Microsoft IMSL mathematical and statistical libraries! Seamless interface with FORTRAN PowerStation allows you to port Fortran code developed on other platforms — including calls to the

IMSL libraries — to the PC. 1,000 precoded, tested, robust routines. Reduce application development time by using the extensive online Help.

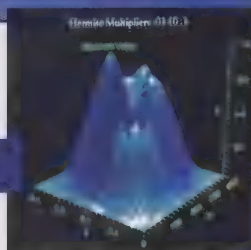
DOS & Windows price\$495
Windows NT price\$495

IMSL C NUMERICAL AND GRAPHICAL LIBRARIES from Visual Numerics[™]

Optimized for Microsoft Visual C++ Compiler

Save 75-95% of source code development. Mathematical, statistical, 2D and 3D graphical subroutines written in C. Includes full online documentation with hundreds of copy-and-paste code examples. FORTRAN libraries also available.

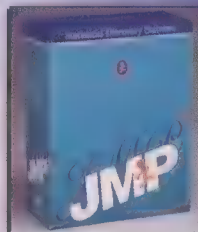
Windows NT price\$1,149



Mathcad PLUS 5.0

Solve mathematical calculations in a live and interactive environment. Type equations right on the screen, add an "=" sign, and Mathcad solves instantly. The solutions are "live." Change any factor ■ equation and Mathcad PLUS 5.0 automatically recalculates. Mathcad PLUS lets you convey ideas without rewriting. And incorporate text and graphics with your real math notation for meaningful and impressive documents.

Windows price\$295



JMP[®] 3.1 Statistical Discovery Software from SAS Institute, Inc.

Statistics is not just data reduction and analysis, it's data discovery. JMP's unique graphical approach to statistics allows you to see your data from many different perspectives quickly, easily. JMP's ever-growing list of statistical features includes: extensive linear and nonlinear model fitting, including regression, ANOVA, MANOVA, and random effects models. Statistical quality control analysis, extensive survival analysis, and exclusive integrated design of experiments. Available for Windows 2nd Quarter '95 — Call.

Mac (Power Macintosh & 68K)\$649

LAHEY FORTRAN 90

Don't use a 77 compiler when there is Lahey Fortran 90. Running on a Pentium, LF90 generates faster executables than any other Fortran compiler (77 or 90). Run all your 77 programs with LF90 and take advantage of new Fortran 90 features: array expressions, data types, new control features, new intrinsic functions, modules, procedures, better array handling, etc. The suite of development tools (editor, debugger/profiler, make, video graphics), 4GB capacity and 32-bit design make LF90 ideal for writing new code and moving older programs to your PC.

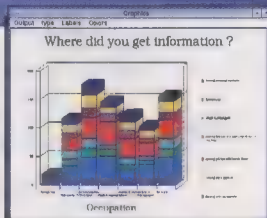
DOS price\$859



Question

Easy-to-use survey software for Windows that makes it easy to design, administer and analyze survey data. Questionnaire design automatically creates validated data entry screens. Includes comprehensive descriptive and multivariate statistics including correspondence analysis, t tests, multiple regression and easy-to-customize graphics. Lexical analysis lets you process open-ended questions. Disponible en version française.

Windows price\$595



To order or for more information call
1.800.622.3345
ask for our free 116-page catalog with
more than 1,850 products!

Resellers call 1.800.622.3320

SciTech SciTech International, Inc. 2525 N. Elston Avenue, Chicago, IL 60647-2003
Tel 312.486.9191, Fax 312.486.9234, URL <http://www.scitechint.com/scitech/>
For Catalog: Circle No. 33
Resellers: Circle No. 34

EEs' tools & toys

Exerciser plugs holes in PCI system development

Now that much of the computer industry has accepted the Peripheral Component Interconnect (PCI) bus, suppliers are under the gun to bring PCI-compatible products to market quickly. But sometimes schedules slip because developers must await delivery of certain application-specific chips or other hardware. The E2910A PCI Bus Exerciser from Hewlett-Packard Co. shortens the wait by simulating the bus traffic that the missing device ought to be there to generate.



▲ Comprising several plug-in cards [center], cabling, and an extensive array of Windows-based system software, the Hewlett-Packard E2910A PCI bus exerciser can deterministically simulate the bus traffic of a not-yet-available device, so that its absence need not hamper system development.

Nor is that all. The E2910A can also act as a bus controller, monitor, and recorder. It is, in sum, a general-purpose tool for developing PCI bus products.

Physically, the package consists of a suite of Windows-based system software, three cards, adapters, and assorted cabling. The test sequencer card plugs into a PC; the bus exerciser card plugs into the system under development by means of a choice of adapters; and an IEEE-488 card connects the PC with an HP 16500A/B logic analyzer. (Neither PC nor logic analyzer is supplied as part of the package.)

The test sequencer card, which runs at up to 33 MHz, controls the bus exerciser card. It allows the user to define complex sequences of transactions, with triggering or branching on system events detected by the logic analyzer or by the bus exerciser itself.

The bus exerciser generates user-defined transactions, whether acting as a master or a target. It includes a protocol monitor, which continually monitors 30 PCI protocol rules in real time. If it de-

tects a violation, it generates a signal that may be used for triggering or branching. In addition, the bus exerciser also generates sideband signals synchronized to bus transactions.

The E2910A PCI bus exerciser sells for US \$44 900. The required logic analyzer will add about \$18 000 to that cost, and an appropriate 486- or Pentium-based PC may add a further \$1500-\$2000. Contact: Hewlett-Packard Co., Direct Marketing Organization, Box 58059, MS51L-SJ, Santa Clara, CA 95051-8059; toll-free, 800-452-4844, ext. 8917; or **circle 100**.

software

DADiSP now does neural nets

Of three new add-on modules for the popular DADiSP graphical scientific and engineering spreadsheet from DSP Development Corp., the most interesting enables users to build and run the back-propagation type of neural network. Called DADiSP/Neural Net, the add-on is a menu-driven module that could find wide application in such areas as speech and pattern recognition, image processing, and cluster analysis. The PC version of DADiSP/Neural Net is priced at \$695 for PCs.

The other two modules do signal processing. The first, DADiSP/Filters 3.0, which offers finite- and infinite-impulse response (FIR and IIR) filtering functions, now includes Kaiser window filtering. The module allows both the time- and frequency-domain characteristics of a filter to be displayed and manipulated. The filter coefficients are displayed in a window of their own and saved in a system file for further use.

Over and above designing a host of common filters (such as Butterworth,

Chebyshev, elliptical, Hilbert, and Remez), DADiSP/Filters 3.0 can calculate and plot the zeroes of an IIR or FIR filter; calculate the group delay of an IIR filter; and perform a variety of conversions from one filter type to another.

Finally, DADiSP/AdvDSP 1.0 performs a variety of advanced digital signal-processing functions—fast Fourier transforms (FFTs), power spectral density estimation, digital interpolation, and cepstrum analysis, to mention a few. It can execute over 20 high-level algorithms, such as chirp Z transforms, zoom FFTs, Yule-Walker linear prediction, and Burg method (maximum entropy) estimations.

DADiSP/Filters 3.0 and DADiSP/AdvDSP 1.0 are each priced at \$495 for PCs and \$995 for workstations. Contact: DSP Development Corp., One Kendall Square, Cambridge, MA 02139; 617-577-1133; fax, 617-577-8211; or **circle 101**.

Keller measurements—free

One of the many problems faced by microwave and RF engineers is determining and maintaining the integrity of their measurements. What with reflections and losses occurring at each and every connection, the errors mount up, but to what extent, it is not always easy to determine.

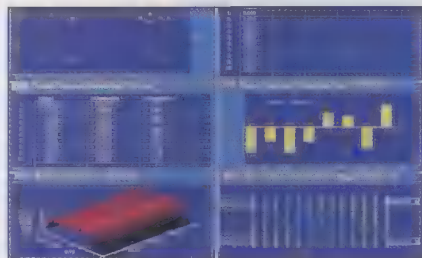
Now Anritsu Wiltron Sales Co. is offering a free software program for improving the quality of scalar return-loss measurements. It calculates the return-loss uncertainty due to cascaded errors based on data (like directivity, test port match, and insertion loss) entered by the user. It can also take into account the effects of adapters.

Both DOS- and Windows-based versions are available. There is no charge for either. Contact: Anritsu Wiltron Sales Co., 685 Jarvis Dr., Morgan Hill, CA 95037; 800-230-AWSC; fax, 408-778-0239, or **circle 102**.

Your first fuzzy system

For many, the highest hurdle in building a fuzzy system is the first one—getting started. Once they have a more or less working model in place, most new users probably know at least one way to tune it. But choosing the initial rule base and fuzzy sets can be a problem.

That is where Rule Maker from HyperLogic Corp. can help. An add-on to the company's CubiCalc line of fuzzy logic development tools, Rule Maker generates fuzzy systems from data supplied to it by the user.



▲ An add-on module for DADiSP from DSP Development Corp., DADiSP/Neural Net is an algorithm for building and running back-propagation neural networks. As this screen shot illustrates, just about any aspect of the network's operation may be displayed and analyzed.

EEs' tools & toys

Because no single approach is best for all systems, Rule Maker incorporates several. For cases in which the available data is too sparse for a neural network approach to work, Rule Maker can choose among its other approaches, including statistical, analytic, and heuristic methods.

According to the company, almost any situation is covered by one of the methods incorporated in the product. Rule Maker can create systems with up to nine input variables and three output variables. The introductory single-copy price of Rule Maker is \$195 in North America and \$250 elsewhere. *Contact: HyperLogic Corp., 1855 East Valley Parkway, Suite 210, Escondido, CA 92027; 619-746-2765; fax, 619-746-4089; or circle 103.*

Instrumentation

DMM is precise—and fast

In these days of low budgets and emphasis on value, an instrument that can double as a stand-alone precision bench-top digital multimeter and a fairly fast



▲ Surprisingly easy to use despite its 13 distinct functions, the Keithley Model 2000 DMM uses no menus. A few key presses set up any measurement on the 6-1/2-digit meter.

component for an automatic test system has special appeal. Such an instrument is Model 2000 from Keithley Instruments Inc., a 6-1/2-digit DMM that delivers 30 triggered readings per second over the IEEE-488 bus at full resolution. At lower resolutions, the meter is even faster, producing, for example, 1000 readings per second at 4-1/2 digits.

Whether standing alone or part of a system, the 2000 fairly oozes versatility. It has 13 built-in measurement functions:

ac and dc voltage; ac and dc current; two-wire resistance; four-wire resistance; frequency; period; decibels; decibels referred to millivolts; temperature (supports J, K, and T-type thermocouples); continuity; and diode test.

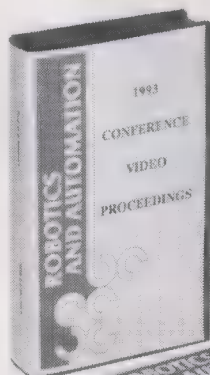
To turn the meter into a small, stand-alone test system, there is a small back-panel slot into which a 10-channel scanner card or a nine-channel thermocouple scanner card may be plugged.

The Model 2000 has a basic 90-day voltage uncertainty of 0.002 percent of reading for dc and 0.05 percent for ac. For four-wire resistance, the basic 90-day uncertainty is 0.008 percent of reading.

The instrument is electronically protected against overloads of up to 1000 V across its input terminals and up to 1500 V from the high input terminal to ground. It sells for \$995. *Contact: Keithley Instruments Inc., 28775 Aurora Rd., Cleveland, OH 44139; 216-248-0400; toll-free, 800-552-1115; or circle 104.*

BACK BY POPULAR DEMAND, THE LATEST CONFERENCE VIDEO PROCEEDINGS IN ROBOTICS AND AUTOMATION!

1994 ROBOTICS AND AUTOMATION CONFERENCE VIDEO PROCEEDINGS



*Sponsored by
the 1994 IEEE
International
Conference on
Robotics and
Automation*

You won't want to miss this compilation videotape, which focuses on the latest information available from robotics and automation intelligence sources from around the world! This important video explains the advances that have taken place and shows the results in practice. Grouped into six categories, the 1994 video covers such topics as:

- Design and Mechanisms
- Sensing and Inspection
- Control
- Mobility
- Applications
- Simulation Programming and Teleoperation

This video and accompanying booklet of abstracts will become your one-stop reference source for robotics and automation information!

For fastest service, call toll free (in USA)

1-800-678-IEEE

fax 1-908-981-9667; phone 1-908-981-0060



The Institute of Electrical and Electronics Engineers, Inc.

IEEE Member Price: \$80.00
List Price: \$130.00
IEEE Order No. (INTS) HV5777-PDN
ISBN (INTS) 0-7803-2262-5
IEEE Order No. (PAL) HV5785-PDN
ISBN (PAL) 0-7803-2251-5

literature

IEEE standards for 1995

Developing and disseminating industry standards is one of the IEEE's most important activities, so the availability of the Institute's 1995 *Standards Products Catalog* should interest many readers. More than 700 IEEE electrotechnology standards publications are listed in the compendium, which is offered free of charge.

The catalog may be downloaded electronically in three ways:

- From the IEEE's electronic bulletin board system (BBS) at 908-981-0035.
- From the Internet, via the World Wide Web, at <http://stds.ieee.org:70/0/pub/ieeestds.htm>.
- From the Internet, by way of Gopher and FTP, at <stdsbbs.ieee.org> (IP address 140.98.1.11).

For a paper copy, **circle 105**.

new & noteworthy

What are believed to be the industry's first **3-V silicon avalanche transient voltage suppressors** have been announced by ProTek devices, Tempe, Ariz.

Designed and characterized specifically for 3.0/3.3-V applications, the devices have a peak power rating of 500 W for an industry-standard 8/20- μ s pulse—a pulse with a front time, from zero to peak value, of 8 μ s and a decay time, to 50 percent of peak value, of 20 μ s. The parts have a theoretical response time of 10 ps, and a maximum clamping voltage of 6.5 V at 1 A. **Circle 106**.

• The 1995-96 **Test and Measurement Catalog and Reference Guide** produced by Keithley Instruments Inc., Cleveland, Ohio, includes comprehensive technical data, specifications, selection guides, and application information on the company's extensive line of test equipment and accessories. Among the instruments covered are digital multimeters with resolutions from 4-1/2 to 8-1/2 digits, electrometers, switching cards, scanner cards, and even an entire system for testing flash memories. The 256-page tome is offered free of charge. **Circle 107**.

• Sharp Electronics Corp., Camas, Wash., has introduced a **primary-side switching voltage regulator** that combines a power MOSFET and a switching

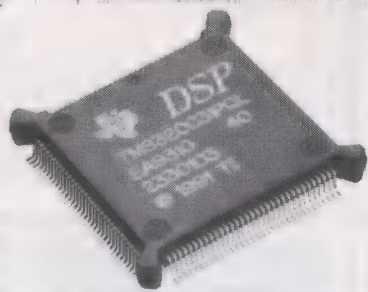
control IC in a single TO-220 package. Its output device can sustain a maximum drain-to-source voltage of 500 V and a maximum drain current of 4.5 A. Its allowable dissipation varies from a low of 2 W (in free air with no heat sink) to 20 W (with a theoretical infinite heat sink). The Model PQ1PF1 regulator sells for \$5.39 in hundred-piece lots. **Circle 108**.

• A **wideband (300-MHz) operational amplifier** that draws at most a mere 1 mA from a single 5-V supply has emerged from Analog Devices Inc., Wilmington, Mass. The AD8011 is aimed at applications in portable video equipment, communication systems, graphics workstations, document scanners, and data acquisition. It slews at 3500 V/ μ s and settles to within 0.1 percent in 25 ns. Its worst-case harmonic distortion is quoted at -62 dB at 20 MHz while driving a 150- Ω load. The AD8011 is priced at \$1.95 in 1000-piece lots. **Circle 109**.

MICHAEL J. RIEZENMAN, Editor

Consultant: Paul A.T. Wolfgang, Boeing Defense & Space Group

1200 bps VOICE CODEC



Features:

- Performance equivalent to 2400 bits/s DoD LPC-10c
- Military and commercial applications:
 - Cellular radio
 - Tactical communications
 - High gain multiplexers
 - HF/VHF packet radio
 - Full duplex channel on single TMS320C3X
 - Linkable object and source code license available
 - Link Margin extension
 - Voice annotation
 - Rural telephony/thin route
 - Paging services

TECHNICAL EXCELLENCE IN SYSTEMS,
SERVICES
AND PRODUCTS FOR GLOBAL COMMUNICATIONS



COMSAT Laboratories
22300 COMSAT Drive, Clarksburg, MD 20871 USA
Tel: (301) 428-4553 Fax: (301) 428-4634
<http://www.comsat.com> info@ctd.comsat.com

Circle No. 4

You Now Have Many More Good Reasons To Use SES' Engineering Software...



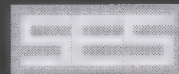
Introducing...

CODES™
ANALOGING™
MULTIGROUND™
MultiFields™
MultiLines™

Grounding, Line &
Cable Parameters,
Electromagnetic
Fields, Lightning
and Transient
Interference

- Fast & accurate analysis
- Low & high frequency and transient grounding analysis
- Line constants for conductors and complex cable configurations
- Current distribution in wires, neutrals, shields and cable paths
- Electromagnetic & lightning interference in common modes
- Frequency and time domain analysis of electromagnetic fields generated by an array of energized conductors (cable, bus, antenna & distribution lines, etc.)

SES' worldwide R&D services keep enhancing the accuracy, quality, and capabilities of its products to provide the closest simulation in the dust (all in our software running on a table-top computer). Now, these new versions release all their engineering power through a smart and intuitive windows-based interface which dramatically increases users' productivity, productivity those with an electrical engineering background. Just describe your case, and let the program take care of the rest.



SES Engineering Services & Technologies Ltd.
1544 Ave. Montreal, Quebec, Canada, H3M 1G4
Tel: (514) 336-2511 Fax: (514) 336-6144
1-800-668-3737 (US and Canada)

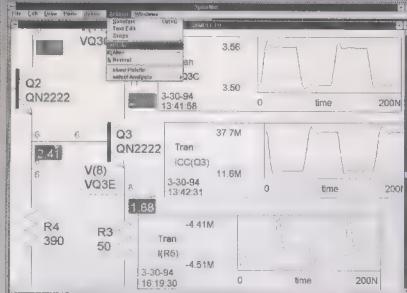
Circle No. 15

The Product Profiles advertising section provides a monthly, distinctive focus on both new and commercially established products and services. They offer practical solutions for engineering and scientific professionals in today's fast-paced, rapidly changing high-tech environment.

Circle the corresponding number on the Reader Service Card.

Analog Circuit Simulation

Windows, Windows NT, DOS & Macintosh



- Interactive SPICE Simulator, **IsSPICE4**
- Completely Integrated Schematic Entry
- Real Time Graphics • Affordable Prices

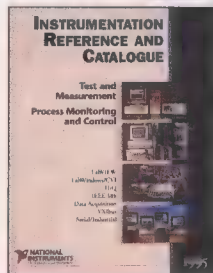
Call Or Write For Your Free Demo and Information Kit!

Fax 310-833-9658 P.O. Box 710 San Pedro
Tel. 310-833-0710 **intusoft** CA 90733-0710

Circle no. 51

INSTRUMENTATION REFERENCE AND CATALOGUE

Test and Measurement Process Monitoring and Control



Free Instrumentation Reference and Catalog

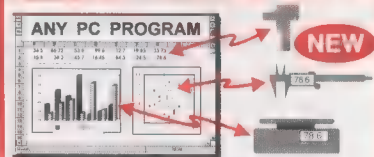
National Instruments is providing a 1995 catalog detailing computer-based data acquisition, instrument control and data analysis products. Includes information on exciting new products and technologies such as Plug and Play boards, Power Macintosh software, Test Executives, SPC and SQL add-ons, HP-UX instrument control, PCMCIA interfaces and VXIplug & play. There is also information on customer education classes. Includes tutorials and glossary.

National Instruments
6504 Bridge Point Parkway
Austin, Texas 78730
(512) 794-0100
(800) 433-3488 (US and Canada)
Fax: (512) 794-8411

Circle no. 52

RS232 Direct Into Any PC Program

ANY PC PROGRAM



Read Real-Time Data from Any Serial Device into Any Application - Lotus, dBASE, Excel, etc. Full 2-way I/O with many advanced features. No Hardware or Programming Required!

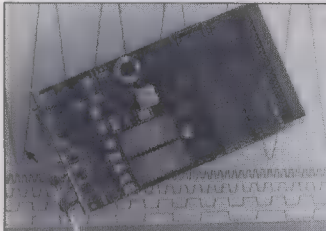
The SoftwareWedge™
The Ultimate Data I/O Solution

For Free Info. Call 800-722-6004
DOS ver. \$159, Windows ver. \$199. Pro ver. Available

TAL T.A.L. Enterprises, 2027 Wallace St., Philadelphia, PA 19130. (215) 763-2620

Circle no. 53

ULTRAFast SBus A/D



5 MHz DATA ACQUISITION

The ultimate 12-bit data acquisition board can acquire 8 Million A/D samples while simultaneously outputting 8 Million D/A samples and TTL vectors, from your SUN Workstation.

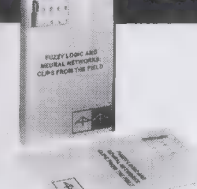
Four analog inputs, twin 5 MHz 12-Bit A/D and D/A converters, and huge 16 MB RAM allow use in the most demanding scientific and industrial applications.

ULTRAVIEW CORP., 475 Yampa Way, Fremont, CA 94539
PHONE (510) 657-9501
Fax (510) 657-0927

Circle no. 54

FUZZY LOGIC AND NEURAL NETWORKS

Clips from the Field



This video program consists of video clips documenting significant achievements and current advances in the fields of fuzzy logic and neural networks.

IEEE Member Price: \$120.00 List Price: \$150.00
NTSC Order #: HVO330-1-PZO ISBN 0-7803-0366-0
PAL Order #: HVO334-3-PZO ISBN 0-7803-0376-8

For service, call
1-800-678-IEEE
(Outside the U.S.) or fax: 1-908-981-9667

Circle no. 55

QUICK TURN QUICK TURN

PROTOTYPE CIRCUIT BOARDS

UP TO 8 LAYERS IN 24 HRS

MULTI LAYERS

- Up to 30 Layers
- Blind & Buried Vias
- Flex & Rigid Flex
- Controlled Impedance
- Thin Cores - .002
- Controlled Dielectrics

LAMINATES

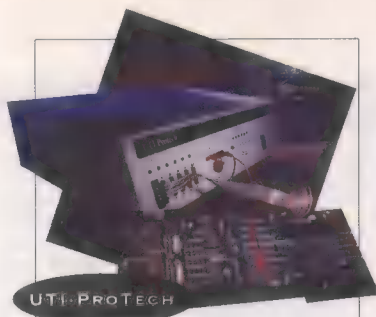
- FR-4
- Teflon
- Polyimide
- Any specialty lamination - Cyanate Ester, BT

FINE PITCH CAPABILITY

- UL Approved-2 mil Lines
- Surface Mount & Conventional Design
- Selective Gold Solder
- In-house Laser Photoplotting

DEH Printed Circuits, Inc.
840 Church Road, Elgin, IL 60123
(708) 468-0001 Fax (708) 468-0002
24 Hour Modem (708) 468-0003

Circle no. 56



UTi-PROTECH

BOARD REPAIR

- Easy to use in-circuit clip tester
- Rapidly locate defective components
- Repair boards quickly and economically
- Graphical on-screen operator guide
- Test programs that "learn" from your powered circuit boards
- Pre-programmed device test library
- 32 to 128 pin test capability



UltraTest International, Inc.
142 Charon Avenue San Jose, CA 95131
408-433-2244 Fax: 408-433-5508

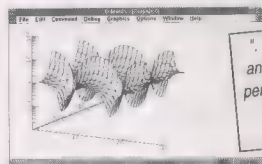
DISTRIBUTOR INQUIRIES INVITED

Circle no. 57



Reduce
Development Time.
Increase Performance.
Improve Results.

A high-performance integrated data analysis tool with a high-level matrix language, extensive graphics, functions, and a debugger.



"... a useful tool for anyone who needs to perform data analysis."
—John Cratty, IEEE Computer

Statistics • Optimization • Integration • Filtering • ODEs • FFTs
Matrix factorization • AR simulation • Spectral analysis • and More

\$395 Unconditional Money-back Guarantee

HARMONIC SOFTWARE, INC.
206-367-8742 • FAX 206-367-1067
harmonic@world.std.com

Circle no. 58

★ COME TO THE SOURCE ★

WBC Licenses 8-bit & 16-bit
core microprocessors in
cubed in your ASICs



From the Original Designers and Owners
of 65C02 and 65C816 Technologies

- Low Power • Low Gate Count
- Efficient, Well-Defined Instruction Set
- Sub-Micron Process Independence
- Hard Core, Verilog, and HDL Models Available
- Wide Variety of Hardware and Software Support

The Western Design Center, Inc.
Phone: (602) 962-4545 Fax: (602) 835-6442
e-mail: wdesignc@indirect.com

Circle no. 59

Gain approval of top managers
from this hands-on reference to better
communications techniques

WRITING IN THE TECHNICAL FIELDS

A Step-by-Step Guide for
Engineers, Scientists, and
Technicians

by Mike Markel,
Boise State
University

This comprehensive and informal guide combines leading-edge research with practical advice and provides a simple, effective system for writing any kind of technical document.



IEEE Member Price: \$17.50 List Price: \$21.95
(softcover) Order #: PP0385-5-PZN (sc)
IEEE Member Price: \$25.00 List Price: \$29.95
(hardcover) Order #: PC0385-5-PZN (hc)

For fastest service, call

1-800-678-IEEE
(1-908-981-0060 outside the U.S.)
or fax: 1-908-981-9667

The Institute of Electrical and Electronics Engineers, Inc.

Circle no. 60

Your Ad Here!

YOUR HEADLINE

This area may be used by advertisers to detail their ad message in 50 words or less. Just provide typed copy with appropriate direction for emphasis (bold, underscore, etc.) we'll do the rest. Be sure to include repros of your company logo, etc. Indicate if you wish us to set addresses, phone #, etc. For rates phone 212-705-7312 and production information, phone 908-562-6334.

COMPANY NAME/LOGO HERE

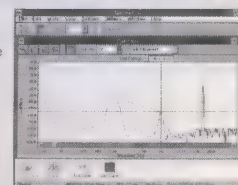
Mailing Address/Phone

AD SIZE: 2 1/2" x 3"

Turn Your Multimedia PC into a Powerful Real-Time Spectrum Analyzer

Features

- Dual channel FFT Analyzer
- Narrowband and 1/3 Octave
- Real-Time, Record, Playback or Post Process
- Time Series, Spectrum, Phase, 256 Color Spectrogram and 3-D Surface plots
- FFT sizes through 16,384 pts
- Digital Filtering
- Signal Generation
- Decimation and Triggering
- Overlap Processing



Call Now for Free Demo!
1-800-401-3472

Applications

- Acoustic Research
- Distortion Measurements
- Noise Analysis
- Frequency Response Testing
- Vibration Measurements
- Transfer Function Measurements

System Requirements

- 386/486/Pentium and Windows 3.1
- Windows compatible sound card
- 4 MB RAM minimum
- Mouse and Math coprocessor
- 256 Color VGA (for spectrogram)

\$395 Software only

\$629 Software plus pro quality sound card

Affordable Signal Processing Software

PHS Precision Hill Software
2400 Main Rd., NY
Poughkeepsie, NY 12601

Spectra Plus
Professional Edition

Tech Info: 360-697-7733 • Fax: 360-697-7730 • BBS: 360-697-7717

Circle no. 61

The best introductory textbook by a
computer margin...no one who works with
neural networks should be without this book.
—James A. Anderson, Brown University

NEURAL NETWORKS A Comprehensive Foundation

by Simon Haykin,
McMaster
University



IEEE Member Price: \$56.00 List Price: \$69.95
Order #: PC0403-6-PZN

For fastest service, call

1-800-678-IEEE
(1-908-981-0060 outside the U.S.)
or fax: 1-908-981-9667

The Institute of Electrical and Electronics Engineers, Inc.

Circle no. 62

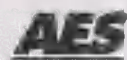
Learn MICROCONTROLLERS EMBEDDED SYSTEMS and PROGRAMMING with the New AES-10

The AES-10... a complete learning system, a complete embedded control system. Extensive manuals guide you through your 8051 development project. Assembly, BASIC, and C programmable. All hardware details, complete schematics. Learn to program the LCD, keypad, digital and analog I/Os. The entire board is software reconfigurable for your applications. Everything you need, nothing extra required.

80C32 Computer/Microcontroller board with:

- 32K Byte ROM • 32K Byte RAM • 2 by 16 Liquid Crystal Display • 4 by 5 Keypad • Two serial ports
- 5 interrupt • 3 timers • A/D, D/A, PWM and digital I/O • Built in Logic Probe • Power supply (can also be battery operated) • Extended Intel BASIC and AES Monitor in ROM • RS-232 cable • connect to PC for programming • 8051/52 DOS Cross Assembler • Program disks with well documented examples • User's Manual, Language Manual, and Text (over 400 pages).

AES-10 \$285 Complete Free Info Pack, M/C Visa
Money Back Guarantee 714-550-8094
Fax 714-550-9941

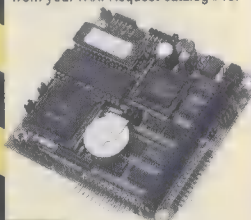


CALL 1-800-730-3232

970 W. 17th St., Santa Ana, California, 92706 USA

Circle no. 63

Keyboards
RS232/RS485
Real-Time Clock
Parallel I/O
Relay Drivers
Battery Backup
ADC/DAC
1M RAM/ROM
LCDs



1724 Picasso Ave.
Davis, CA 95616
916.757.3737
916.753.5141 FAX

Circle no. 64

CLASSIFIED EMPLOYMENT OPPORTUNITIES

The following listings of interest to IEEE members have been placed by educational, government, and industrial organizations as well as by individuals seeking positions. To respond, apply in writing to the address given or to the box number listed in care of *Spectrum* Magazine, Classified Employment Opportunities Department, 345 E. 47th St., New York, N.Y. 10017.

ADVERTISING RATES

Positions open—\$40.00 per line, not agency-commissionable.

Positions wanted—\$40.00 per line, a 50% discount for IEEE members who supply their membership numbers with advertising copy.

All classified advertising copy must be received by the 25th of the month, two months preceding the date of issue. No telephone orders accepted. For further information call 212-705-7578. IEEE encourages employers to offer salaries that are competitive, but occasionally a salary may be offered that is significantly below currently acceptable levels. In such cases the reader may wish to inquire of the employer whether extenuating circumstances apply.

Academic Positions Open

Texas A&M University: The Electrical Engineering Department expects to have several openings for tenure track faculty at all ranks. Applicants must have ■ Ph.D. degree or the equivalent or completion of all requirements by date of hire. For senior positions, applicants should have ■ proven record of scholarly contributions, and for junior positions, demonstrated potential for quality research and teaching is necessary. The salary is competitive and commensurate with qualifications and experience. Applicants are sought in the areas of computer engineering, microelectronics, power electronics, signal processing, and medical electronics. Applicants should send a complete resume, including names and addresses of three references to Dr. A.D. Patton, Department Head, Electrical Engineering Department, Texas A&M University, College Station, TX 77843-3128. Texas A&M University is an equal opportunity/affirmative action employer and actively seeks the candidacy of women and minorities.

Ghulam Ishaq Khan Institute of Engineering Sciences and Technology: Faculty of Electronic Engineering & Faculty of Computer Science invite applications for faculty positions at all levels. Applicants must have ■ Ph.D. from ■ recognized University with a strong commitment to teaching, research, and publications. The Institute offers nationally competitive salaries and generous fringe benefits. The applicants should submit ■ curriculum vitae with names of three references to the Rector, Ghulam Ishaq Khan Institute of Engineering Sciences and Technology, Topi, District Swabi, N.W.F.P. Pakistan. Fax # (92) 5372-71865. The Institute is an equal opportunity employer which does not discriminate based on sex, race, religion or ethnicity.

Post-Doctoral Research Fellow in Photonics:

The Center for Photonics and Optoelectronic Materials (POEM) at Princeton University is seeking applications from qualified candidates for appointment as a Post-Doctoral Research Fellow to work on the design and growth of indium phosphide-based optoelectronic device structures by gas source molecular beam epitaxy. Prospective candidates should have a PhD in electrical engineering, materials science, physics or associated fields, and should have hands-on in-depth experience with MBE growth fabrication, and characterization of devices such as lasers, modulators, etc. The successful candidate will work on independent research projects, as well as lead and organize larger group activities involving graduate students at all levels

of expertise. Appointments are for one year with the possibility of extension. Salary level depends on experience. Candidates should send their resume and three letters of reference to Prof. Stephen R. Forrest, ATC/POEM, E-Quad. J303, Dept. of Electrical Engineering, Princeton University, Princeton, NJ 08544. Princeton University is an Equal Opportunity Employer.

The University of Kansas Department of Electrical Engineering and Computer Science invites applications for a tenure-track faculty position in the remote sensing area to begin in August 1995. Applicants at the rank of assistant professor and associate professor will be considered and must have ■ Ph.D. in electrical engineering or physics. The successful candidate is expected to teach and supervise students both at the undergraduate and graduate levels and conduct research in remote sensing or RF/microwave engineering. Applicants with ■ Ph.D. in physics must have research experience in microwave remote sensing or RF/microwave engineering. Assistant professor candidates should have ■ high potential for both teaching and research. Applicants for the rank of associate professor should have a distinguished research record and a strong interest in educational programs. Applications, including resume, description of teaching and research interests, and the names and addresses of at least three references, should be sent to Professor Prasad Gogineni at EECS Department, 1013 Learned Hall, University of Kansas, Lawrence, Kansas 66045. Applications received until the position is filled will be considered. The University of Kansas is ■ EO/AA employer.

The University of Cincinnati, Department of Electrical & Computer Engineering and Computer Science: Applications are solicited for a tenure track faculty position in Electrical and Computer Engineering starting January, 1995. The prospective faculty member should have an earned Ph.D. in electrical engineering or applied physics. Applicants with expertise in high speed optoelectronic device fabrication and characterization are sought. The faculty member will be involved in research and teaching at both undergraduate and graduate levels. The individual will collaborate with established research programs in the area of nano/optoelectronics. Facilities in the department include a complete microfabrication facility, specialized equipment for plasma and reactive ion etching, focused ion beam implantation, chemical vapor deposition, molecular beam epitaxy, laser optical characterization, etc. The Department offers MS/Ph.D. programs in electrical engineering, computer engineering, and computing sciences as well as an ABET fully-accredited under-

graduate program in Electrical and Computer Engineering. The Department has 45 full-time faculty, 240 full-time graduate students, 400 undergraduate students. Curriculum vitae and the names of three references should be sent to: Prof. Peter B. Kosel, Interim Head, Department of Electrical & Computer Engineering and Computer Science, P.O. Box 210030, University of Cincinnati, Cincinnati, Ohio 45221-0030. The University of Cincinnati is an Affirmative Action/Equal Opportunity employer and encourages and welcomes applications from women and minorities.

Postdoctoral/Research Faculty in Theoretical, Computational, and Experimental Chemistry and Physics: We are looking for exceptionally able (1) theoretical/computational chemists or physicists with a strong background in quantum or classical dynamics, intense light-matter interactions, quantum control of chemical dynamics, or related areas, (2) experimentalists, particularly with a background in one or more of the following: ultrafast lasers, atomic and molecular beams, laser generated x-rays, charged particle beams, or x-ray physics. Current research interests in our group include (1) theoretical and experimental quantum control of chemical dynamics with femtosecond lasers, (2) development of multi-terawatt femtosecond lasers and their application to high field chemistry and physics, (3) ultrafast, short wavelength electron and x-ray diffraction as applied to imaging molecular quantum dynamics. For ■ description of current group activities and personnel see our World Wide Web site, <http://www-wilson.ucsd.edu/> or send email with no text to "wilsjob@ucsd.edu". To apply, please send ■ cv to Prof. Kent R. Wilson, Department of Chemistry 0339, University of California, San Diego, La Jolla, CA 92093-0339. Affirmative Action/Equal Opportunity Employer.

Rice University, Department of Electrical and Computer Engineering invites applications for an Assistant Professor level, tenure track faculty position in the area of telecommunication and communication networks, to begin in August 1995. Applicants must have a doctorate in Electrical Engineering, or ■ closely related field. Rice University is ■ small private university with a strong commitment to excellence in both research and teaching. The ECE Department has extensive computing and laboratory facilities. The Department of Electrical and Computer Engineering has close ties and active collaboration with the Department of Computer Science and the Department of Computational and Applied Mathematics. Applicants should submit their resume, a summary of their research accomplishments, and the names of at least three references to the Chairman of the Department of Electrical and Computer Engineering, Rice University, P.O. Box 1892, Houston, TX 77251-1892. Rice University is an equal opportunity/affirmative action employer.

Philadelphia College of Textiles and Science - Computer Science: Assistant Professor. Tenure-track. Ph.D. in computer science or computer engineering required. We seek candidates with backgrounds in computer architecture or software engineering who are interested in research interactions with faculty in the fuzzy logic and neural networks areas. Responsibilities include teaching undergraduate and graduate courses, advising students and developing and conducting sponsored research programs. The science department

currently has strong research programs in fuzzy set theory and applications, high speed computing and computational mathematics. Computing environment includes multimedia PC and Macintosh clusters, VAX 8250, separate UNIX network, Silicon Graphics and DEC Alpha AXP workstations, and access to Cray C90 supercomputer. Submit letter of application, curriculum vitae, statement of teaching and research interests and names, addresses and telephone numbers of three professional references to Dr. Richard A. Nigro, Vice President for Academic Affairs, Philadelphia College of Textiles and Science, School House Lane and Henry Avenue, Philadelphia, PA 19144. Applications reviewed beginning March 20, 1995 until positions are filled. PCT&S is an Affirmative Action, Equal Opportunity Institution.

Dean of the College of Engineering: Applications are invited for the position of Dean of the College of Engineering at the University of Massachusetts Lowell. The appointment will commence June 1, 1995 or as soon as possible thereafter. The University: The James B. Francis College of Engineering at the University of Massachusetts Lowell traces its origins to 1895, with the founding of the Lowell Textile School. Through 100 years of growth and development, the fundamental purpose of the school has remained constant: to prepare men and women for their entrance into the engineering profession, providing the leading industries in our region with skilled technical professionals, and to foster new technologies and disseminate them to industry. The College: The College consists presently of seven departments: Chemical and Nuclear, Civil, Electrical, Engineering Technology, Mechanical, Plastics and Work Environment. It is also home to several interdisciplinary research centers and laboratories and will have substantial connections to the newly created Institute for Massachusetts Partnering and Commercialization of Technology (IMPACT). The College has several unique strengths, including plastics engineering and environmental/work environment programs. The Position: The primary role of the Dean of the College is to foster excellence in teaching, research and service by example and through the exercise of vision and leadership. He or she must demonstrate a commitment to quality undergraduate and graduate programs and a record of developing, planning and evaluating these programs in accordance with ABET guidelines. In addition, he or she will also contribute to the development of new programs as part of an engineering - applied science - management continuum and to initiatives designed to recruit and retain minorities and women. To expand the College's already strong relationship with industry, the Dean must demonstrate the ability to represent the College effectively in interactions with the public and private sectors and to articulate the College's goals and plans to a variety of constituencies. Ultimately, the Dean will guide the College toward meeting the University's goal: that each department in the College be ranked in the top quartile for engineering schools. Qualifications: The Dean must have a distinguished academic and research record and experience and knowledge of the national research and funding environment, as well as a record of excellence in academic administration. Salary: The salary is highly competitive with excellent fringe benefits. The Application: Screening of applicants will begin mid-January and continue until the position is filled. The application should consist of: i) a letter of application including discussion of educational and admin-

istrational philosophy and vision; ii) a curriculum vitae; iii) official copy of doctoral transcript; iv) a list of 6 references (names, addresses and telephone numbers). Applications must be addressed to: Dr. Janice M. Stecchi, Co-Chair, Search Committee for Dean of College of Engineering, College of Health Professions, University of Massachusetts Lowell, One University Avenue, Lowell, MA 01854; Tel: (508) 934-4461; Fax: (508) 934-3006; Email: StecchiJ@woods.uml.edu. The University of Massachusetts Lowell is an Equal Opportunity/Affirmative Action, Title IX, H/V, ADA 1990 employer.

Dean, Engineering and Energy, West Virginia University:

WVU is the land-grant institution in the State of West Virginia with 23,000 students in fifteen colleges and schools located in Morgantown. The University is considering combining the existing College of Engineering and College of Mineral and Energy Resources. The combined college will enroll 1300 undergraduate and 700 graduate majors, awarding BS, MS, and Ph.D. degrees across a full spectrum of programs. The colleges now employ 110 full-time faculty and approximately 100 staff, and have over \$13 million in external research funding each year. Candidates should submit a letter of application; curriculum vitae; and the names, addresses and telephone numbers of at least four references. Screening of the applications will begin April 1, 1995 and will continue until the position is filled. Applications and nominations should be directed to: George A. Hedge, Ph.D., Search Committee for Dean of Engineering and Energy, West Virginia University School of Medicine, Research and Graduate Studies, 2267 Health Sciences South, P.O. Box 9104, Morgantown, WV 26506-9104, Telephone: (304) 293-7206. West Virginia University is an Equal Opportunity, Affirmative Action Employer and does not discriminate on the basis of race, color, religion, sex, age, marital status, disability, veteran status, national origin, or sexual orientation. The University attempts to be responsive to dual career couples.

Electrical Engineering - Assistant Professor:

The Electrical Engineering Department at Cleveland State University is seeking applications for a tenure track faculty position at the assistant professor level in the Computer Engineering area. Minimum qualifications: Ph.D. in Computer Engineering, ability to conduct independent research and to teach undergraduate and graduate courses in Computer Engineering and Electrical Engineering. Preferred candidates will also have teaching and industrial experience and publications in Computer Engineering. Full job description on request. Deadline: April 1, 1995 or when filled. Starting Date: September 15, 1995. Send resume and names of three references to: Dr. Pong P. Chu, Chair of Search Committee, Electrical Engineering Department, Cleveland State University, E. 24th & Euclid Ave., Cleveland, OH 44115. Equal opportunity employer, m/f/d. CSU provides reasonable accommodation for individuals with disabilities.

University of Miami, Department of Electrical and Computer Engineering

invites applications for an anticipated tenure-track position in the area of electro-optics. The position will be available in August 1995, and the academic rank will depend upon the qualifications of the successful candidate, including the possibility of an endowed chair. Applicants must possess an earned doctoral degree, be able to teach undergraduate courses in electronics, and show a strong record/commitment to graduate teaching and funded experimental research in

CLASSIFIED EMPLOYMENT OPPORTUNITIES

electro-optics. Possible areas of interest include optoelectronics, integrated optics, and lasers. The College of Engineering encourages interdisciplinary research, and candidates interested in biomedical applications of electro-optics are particularly welcome. The University is located in beautiful Coral Gables, a suburb of Miami, FL. Applications should be sent with the names of three references to: Dr. Tzay Y. Young, Chairman, Department of Electrical and Computer Engineering, P.O. Box 248294, University of Miami, Coral Gables, Florida 33124. The University of Miami is an equal opportunity/affirmative action employer.

The Hong Kong Polytechnic University (formerly Hong Kong Polytechnic) invites applications for the following post:

Department of Electronic Engineering - Professor/Associate Professor in Computer Systems Software and Communication Engineering. The appointee will be required to teach and conduct research up to postgraduate level in one or more of the following areas: Distributed Processing and Systems, Operating Systems and Concurrent Programming, Software Engineering, Data Structure and Database Management Systems, Functional and Object-oriented Design, High Performance Computer Architecture/Intelligent Systems, Neural Networks and Fuzzy Theory/Modern DSP Applications, Speech/Digital TV and HDTV, Mobile Communication and RF Design, High Speed Networks, Fibre Optics, Telecom Software and Networking, Electronic Circuits and Design. The appointee is expected to engage in research planning, research direction and to supervise PhD students. Applicants should have (a) a PhD degree; (b) a strong record in research and publication and research leadership; (c) good capability in teaching; (d) contribution in professional service to the community; and (e) preferably some industrial experience. For appointment at Professor level, a distinguished record of research and scholarship is required. Salary and Conditions of Service - Professor: HK\$669,360 - HK\$889,260 per annum. Associate Professor: HK\$641,580 - HK\$861,900 per annum. (US\$1 = HK\$7.8 as at 9 January 1995) Initial appointments normally made on a fixed term gratuity-bearing contract of two years, at the end of which re-engagement is subject to mutual agreement. Other benefits include leave, subsidized housing, medical and dental schemes, and children's education allowance. Application: Application including curriculum vitae and names of three referees should be sent to the Personnel Office, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong before April 15, 1995. [Fax (852) 2764 3374, E-mail GSSTAFF@HKPCC.HKP.HK].

The Osteoporosis Research Group

(Department of Radiology, Skeletal Section) of the University of California, San Francisco is seeking a computer scientist (Ph.D. level) to further the development of image processing in quantification of bone mineral density, and bone microstructure for osteoporosis research studies. Principal image processing package is Advanced Visual Systems (AVS), utilized for the development of image processing tools to quantify bone density and structure acquired via traditional radiographic technique, magnetic resonance imaging, and two- and three-dimensional tomography. Documentation skills are necessary for presenting these tools for general use. In detail, the work will involve study of image enhancement and registration algorithms; study of segmentation methods

CLASSIFIED EMPLOYMENT OPPORTUNITIES

and application of these to images; development of texture analysis tools; participation in AVS meetings organized to develop and improve personal modules of the participants, and define them for general use; develop (and simplify for general use) image processing algorithms for high resolution magnetic resonance images; and define demonstrations for image processing algorithms on AVS package to represent the work done by the Osteoporosis Research Group. Required skills, knowledge and abilities: Ph.D. in Computer Science; familiarity with image processing techniques, preferably with Advanced Visual Systems software package; and familiarity with UNIX (and VAX/VMS) operating systems. Send resume to Harry K. Genant, M.D., Professor of Radiology, Medicine, and Orthopaedic Surgery, Box 0628, Dept. of Radiology, University of California, San Francisco, CA 94143. Equal Opportunity Employer. Minority groups, women and handicapped individuals are encouraged to apply.

Rensselaer Polytechnic Institute: The Department of Electrical, Computer and Systems Engineering invites applications for a tenure-track position at the Assistant Professor level. The specific area of interest is computer engineering with an emphasis on computer communications networks. This new faculty position is part of a major Engineering Renaissance at Rensselaer initiative designed to position Rensselaer for technological leadership in the 21st century. The ECSE Department is the largest academic unit at Rensselaer and has a rich tradition for both research and education. ECSE is seeking to add top quality faculty who bring innovative approaches to modern areas of research and who can effectively participate in a campus-wide educational initiative in Interactive Learning. ECSE has major programs in multimedia communications and signal processing; robotics, intelligent control and manufacturing; integrated electronics and electronics manufacturing; and energy systems which contribute to a dynamic research environment. In addition to the extensive research facilities of the department, there are excellent opportunities for faculty to participate in interdisciplinary research centers including the Center for Image Processing Research, the Center for Integrated Electronics and Electronics Manufacturing, the New York State Center for Advanced Technology in Automation, Manufacturing and Robotics, the Scientific Computation Research Center and the Center for Composite Materials and Structures. There are also close links between ECSE and the Department of Computer Science. New faculty are eligible for special career start-up arrangements including summer support, equipment, graduate student support and reduced teaching loads to encourage the development of successful research programs. Applications and/or requests for further information should be directed to: Dr. William C. Jennings, Department Head, Electrical, Computer and Systems Engineering, Rensselaer Polytechnic Institute, Troy, NY 12180-3590. Dr. Jennings may be reached by phone at (518) 276-6316 or electronically at jennings@ecse.rpi.edu. Rensselaer is an affirmative action/equal opportunity employer and specifically encourages applications from women and minorities.

Hallym University in Korea: The Department of Electronic and Control Engineering invites applications for faculty positions. Areas of interest include VLSI Design/CAD, Control Systems and Robotics, Neural Networks, Digital/Analog

Circuits, Microprocessors, and Signal Processing, all with emphasis on applications. Industrial/Research experience and/or publication in major journals are a plus. Applications will be accepted until 3 or 4 positions are filled. For more information, e-mail: gmoon@sun.hallym.ac.kr

Sprint Eminent Scholar Chair Professorship in Electrical Engineering at Florida A&M University and Florida State University, College of Engineering: The FAMU/FSU College of Engineering seeks nominations and applications for the newly endowed Sprint Eminent Scholar Chair professorship in electrical engineering. The Sprint professor will take an active leadership role in building both the undergraduate and graduate programs and in developing new research initiatives in electrical or computer engineering. Applicants should hold a doctoral degree in Electrical or Computer Engineering and be eligible for a tenured full professorship as demonstrated by experience and excellence in both teaching and research. Candidates should have a record of distinguished scientific achievement in one or more of the following areas: electro-magnetics, electronic materials and devices, digital signal processing, telecommunication, computer engineering and optoelectronics. The ability to engage in collaborative research and to motivate and inspire students are required attributes. The candidate can expect involvement in the National High Magnetic Field Laboratory which is located next to the College of Engineering and has interests in the development and application of high field magnets in a variety of engineering applications and RF Electronics as applied to Magnetic Performance Spectroscopies. The department presently has 16 full time faculty and is expected to grow to about 25 full time faculty within the next few years. Current faculty expertise is in the areas of electro-magnetics, digital signal processing, magnetic materials, opto-electronics, communications and high performance computing. The department enrolls 600 undergraduates and has a growing graduate program with 60 full time students in M.S. and Ph.D. programs. Applications and nominations should be submitted with a statement of interest and goals, vita, and names of five references to: Prof. Anjaneyulu Krothapalli, Chair, Sprint Eminent Scholar Chair Search Committee, FAMU/FSU College of Engineering, P.O. Box 2175, Tallahassee, Florida 32316. Review of applications will close April 15, 1995. The position will be filled by August 1995. The Florida A&M and Florida State Universities are Equal Opportunity/Affirmative Action employers that encourage applications from minority and women and comply with the Americans with Disabilities act. They are public record agencies pursuant to Chapter 119, Florida Statutes.

Boston University Faculty Position: The Computer Science Department at Boston University's Metropolitan College serves professionals in the Greater Boston area with part-time undergraduate and graduate degree programs. These programs are among the largest of their kind in the Northeast. The department seeks an instructor with technical interest in Networks and Data Communications, beginning in September, 1995. The faculty member will also be expected to spend a significant amount of time advising prospective and current graduate computer science students. Both academic background and industry experience will be considered. A Master's degree, at a minimum, and excellent teaching skills are required. Please send applications, and arrange for three letters of accommodation to

be sent to Dr. Eric Braude, Chair Boston University Metropolitan College, 755 Commonwealth Avenue, Room B4, Boston, MA 02215. Applications will be considered until the position is filled.

University of Tromsø, Norway: The Institute of Mathematical and Physical Science invites applications for two tenured positions as Associate Professor in Electrical Engineering/Applied Physics. The applicants should have a background in one or more of the fields remote sensing, signal/image processing, pattern recognition, measurement technique, micro wave technique, and/or electronic circuit design (preferably analog ASIC). Application deadline is April 1. Applications should be submitted to: Institute of Mathematical and Physical Science, University of Tromsø, 9037 Tromsø, Norway. For more information about the positions and about how to apply for them, please contact Professor Einevoll (phone: +47 776 45165, fax: +47 776 45580, E-mail: gaute@phys.uit.no) or Professor Eltoft (phone: +47 776 45184, fax: +47 776 45580, E-mail: pcte@phys.uit.no)

North Carolina State University, Center for Advanced Electronic Materials Processing - Post-Doctoral Research Position: This NSF Engineering Research Center is an interdisciplinary academic/research program involving faculty, researchers and students from the Departments of Electrical and Computer Engineering, Materials Science and Engineering, Physics, Chemical Engineering and Mechanical Engineering. The goal is to develop processing technology and equipment capability for the fabrication of advanced submicron device structures. Emphasis is on the development of process module clusters for carrying out multiple process steps in an in-situ environment. A post-doctoral research position is available for qualified applicants. This includes supervising students on single wafer processing using RTCVD, RPECVD, RT selective epitaxy and plasma etching. An earned doctorate or equivalent industrial research experience is required. Interested applicants should send resumes and the names, addresses and telephone numbers of three references by April 30, 1995, to: Dr. J.R. Hauser, Center for Advanced Electronic Materials Processing, North Carolina State University, Box 7920, Raleigh, North Carolina 27695. North Carolina State University is an Affirmative Action, Equal Opportunity Employer.

Dean, Erik Jonsson School of Engineering and Computer Science: The University of Texas at Dallas invites nominations and applications for appointment to the position of Dean of the Erik Jonsson School of Engineering and Computer Science and concurrent appointment to the Lars Magnus Ericsson Chair in Electrical Engineering. The University, a Carnegie Foundation "Doctoral University I," emphasizes internationally competitive research by its faculty, selective student admissions, a rigorous curriculum, and a high level of interaction with and service to the multinational technologically sophisticated and managerially intensive businesses and industries headquartered in the region. With a current enrollment of approximately 4500 undergraduates and 4000 graduate students, U.T. Dallas is situated on a spacious 500 acre campus 20 miles north of the central Dallas business district, in the heart of the "Telecom Corridor" complex of residential suburbs and corporate office parks. The Erik Jonsson School offers doctoral and bachelor degrees in Electrical Engineering and in Computer Science, together with masters degrees in those fields and in Engineering Science. Approx-

MOVING?

PLEASE NOTIFY US 4 WEEKS IN ADVANCE

Name _____ IEEE Member # _____

Address _____

City _____

State/Country _____ Zip _____

- Please print.
- This notice of address change will apply to all publications to which you subscribe.
- List new address above.
- If you have a question about your subscription, please call 1-800-678-IEEE.

and should be addressed to: Office of the Provost, Attn: Abby Kratz, The University of Texas at Dallas, P.O. Box 830688 MS-AD23, Richardson, Texas 75083-0688. Review of applications will begin on February 27, 1995 and continue until the position is filled. The University of Texas at Dallas is an Equal Opportunity, Affirmative Action employer and strongly encourages applications from candidates who would enhance the diversity of the University's faculty and administration.

University of Pittsburgh: The Department of Electrical Engineering invites applicants for a full-time tenure track faculty position at the Assistant or Associate Professor level beginning September 1995. The areas of interest are Computer Engineering and Control. Preference will be given to applicants with research expertise in Computer Architecture, Parallel Processing, Computer Vision, Computer Control, Sensors/Actuators; particularly those with applications in Bioengineering or Manufacturing. Candidates must possess an earned PhD degree and be committed to an integrated program of teaching and research. The department consists of 31 faculty supervising 300 undergraduate and 180 graduate students. Applicants should submit a resume, a brief statement of research and teaching interests and the names of five references to: Dr. Marwan Simaan, Chairman, Department of Electrical Engineering, 348 Benedum Hall, University of Pittsburgh, Pittsburgh, PA 15261. Tel: (412) 624-8002. In order to receive full consideration, applications must be received before April 15, 1995. The University of Pittsburgh is an Affirmative Action/Equal Opportunity Employer.

Electronics Engineering Technology: Tenure leading position at the Assistant Professor level in a TAC-ABET accredited Electronics Engineering Technology program at the Omaha campus of the University of Nebraska/Lincoln. The EET program is in the process of being converted into an Electronics Engineering program. Qualifications: Requires earned Ph.D. in

tions, the C/C++ programming language, and X-Windows is necessary. Image and signal processing experience is desirable. Previous experience with magnetic resonance instrumentation and system administration is preferred but not required. Salary will be commensurate with experience. A resume and three letters of recommendation should be sent to: John P. Strupp, Center for Magnetic Resonance Research, University of Minnesota Medical School, 385 East River Road, Minneapolis, MN 55455. Deadline for receipt of applications is March 31, 1995. The University of Minnesota is an equal opportunity educator and employer.

University of Massachusetts, Department of Electrical and Computer Engineering: The Department of Electrical and Computer Engineering at the University of Massachusetts at Amherst invites applications for a tenure-track position in electrical and computer engineering as an associate or full professor. We are seeking candidates in the following areas: (1) wireless telecommunication networks, (2) semiconductor (e.g., VLSI ICs, MCMs) manufacturing, and (3) optical remote sensing. Rank and salary will be commensurate with qualifications. Applicants must have an earned doctorate and a proven record of research funding. Preference will be given to candidates with experimental/industrial experience. The search will continue until the position is filled. Send a resume and names of at least three references to Chair, Search Committee, Department of Electrical and Computer Engineering, University of Massachusetts, Amherst, MA 01003. The University of Massachusetts is an Affirmative Action/Equal Opportunity employer.

Montana Tech's Department of Engineering Science invites applications for the position of Assistant Professor of Engineering Science beginning August 1995. A Ph.D. (M.S. acceptable if accompanied by extensive industrial experience) in Electrical Engineering, Systems Control Engineering, or related field is

EMPLOYMENT OPPORTUNITIES

ng and industrial experience not required. Duties include s and associated laboratories Engineering Science - System concentration (instrumentation, nd machinery, control theory, l electronics.) Screening of start April 17, 1995 and condition is filled. Salary and bensive. Send letter of application, nes of three references to Dr. ead, Department of Engineering ntana Tech, 1300 West Park '59701-8997. EEO/AEE

ch Engineer, University of eley: Department of Materials ineering. Duties include the microfabrication processes for d microfilters, and assistance on of students doing research oject. Requirements: PhD in eering or related fields and in microfabrication, with pref- fS. Salary range: \$54,300- ding on qualifications. Initial 7 months, starting as soon as bintment subject to the avail- ural funds. Application dead- 95. Send CV and three refer- lauro Ferrari, 733 Davis Hall, ornia, Berkeley 94720.

The University of Newcastle (Australia) Department of Electrical and Computer Engineering seeks applicants for a fixed-term appointment (initially 3 years) as Lecturer/Senior Lecturer to teach courses up to post-graduate level in the general area of Electric Power Engineering and conduct research (including the supervision of post-graduate students), in one aspect of Power Plant Engineering, provide research leadership in Power Plant Engineering and develop strong industrial links. Selection criteria essential - PhD in Electric Power Engineering, teaching experience and appropriate industrial experience in Power Engineering. Desirable - skills in the area of life assessment of Power Plant and proven research skills in the area of insulation testing. Salary - Senior Lecturer \$A50,928 - \$A58,724 per annum Lecturer \$A41,574 - \$A49,370 per annum. For appropriate candidate, significant consultative opportunities exist with the industrial sponsor - Pacific Power. For further information and copy of full advertisement contact Associate Professor R. Middleton, 6149 216033 or Professor G. Ledwich, 6149 216083, email eegi@ee.newcastle.edu.au. Applications close 28 April 1995.

Harvard University: We invite applications from candidates at all levels for a faculty position in Electrical Engineering. Individuals with interests in the area of electronics or communications are sought. Candidates should have an interest in design and fabrication at the device or systems level and have a Ph.D. in Electrical Engineering, Computer Engineering, or a related discipline. Responsibilities include teaching in the AB., S.B., and Ph.D programs and having a strong research commitment. Applicants should submit a curriculum vitae and the names, addresses (including email) and telephone numbers of three references to the EE Search Committee, Pierce Hall 217, Harvard University, 29 Oxford Street, Cambridge, MA 02138. Applications should be received by April 30, 1995. Harvard is an Equal

CLASSIFIED EMPLOYMENT OPPORTUNITIES

and application of these methods of texture analysis. AVS meetings organize to improve personal module and define them for general use. simplify for general use algorithms for high resolution images; and define image processing algorithm to represent the work done. sis Research Group. Re edge and abilities: Ph.D. familiarity with image processing preferably with Advanced ware package; and familiarity with VAX/VMS) operating system. Harry K. Genant, M.D., Ph.D. Medicine, and Orthopaedic Dept. of Radiology, University of San Francisco, CA 94141. Employer. Minority group capped individuals are encouraged.

Rensselaer Polytechnic Institute Department of Electrical, Computer Engineering invites applications for a position at the Assistant Professor level in a specific area of interest is with an emphasis on computer networks. This new faculty major Engineering Research initiative designed to provide technological leadership in the 21st century. The ECSE Department is the largest academic unit at Rensselaer and has a rich tradition for both research and education. ECSE is seeking to add top quality faculty who bring innovative approaches to modern areas of research and who can effectively participate in a campus-wide educational initiative in Interactive Learning. ECSE has major programs in multimedia communications and signal processing; robotics, intelligent control and manufacturing; integrated electronics and electronics manufacturing; and energy systems which contribute to a dynamic research environment. In addition to the extensive research facilities of the department, there are excellent opportunities for faculty to participate in interdisciplinary research centers including the Center for Image Processing Research, the Center for Integrated Electronics and Electronics Manufacturing, the New York State Center for Composite Materials and Structures. There are also close links between ECSE and the Department of Computer Science. New faculty are eligible for special career start-up arrangements including summer support, equipment, graduate student support and reduced teaching loads to encourage the development of successful research programs. Applications and/or requests for further information should be directed to: Dr. William C. Jennings, Department Head, Electrical, Computer and Systems Engineering, Rensselaer Polytechnic Institute, Troy, NY 12180-3590. Dr. Jennings may be reached by phone at (518) 276-6316 or electronically at jennings@ecse.rpi.edu. Rensselaer is an affirmative action/equal opportunity employer and specifically encourages applications from women and minorities.

Hallym University in Korea: The Department of Electronic and Control Engineering invites applications for faculty positions. Areas of interest include VLSI Design/CAD, Control Systems and Robotics, Neural Networks, Digital/Analog

and application of these methods of texture analysis. AVS meetings organize to improve personal module and define them for general use. simplify for general use algorithms for high resolution images; and define image processing algorithm to represent the work done. sis Research Group. Re edge and abilities: Ph.D. familiarity with image processing preferably with Advanced ware package; and familiarity with VAX/VMS) operating system. Harry K. Genant, M.D., Ph.D. Medicine, and Orthopaedic Dept. of Radiology, University of San Francisco, CA 94141. Employer. Minority group capped individuals are encouraged.

Department of Electrical, Computer Engineering invites applications for a position at the Assistant Professor level in a specific area of interest is with an emphasis on computer networks. This new faculty major Engineering Research initiative designed to provide technological leadership in the 21st century. The ECSE Department is the largest academic unit at Rensselaer and has a rich tradition for both research and education. ECSE is seeking to add top quality faculty who bring innovative approaches to modern areas of research and who can effectively participate in a campus-wide educational initiative in Interactive Learning. ECSE has major programs in multimedia communications and signal processing; robotics, intelligent control and manufacturing; integrated electronics and electronics manufacturing; and energy systems which contribute to a dynamic research environment. In addition to the extensive research facilities of the department, there are excellent opportunities for faculty to participate in interdisciplinary research centers including the Center for Image Processing Research, the Center for Integrated Electronics and Electronics Manufacturing, the New York State Center for Composite Materials and Structures. There are also close links between ECSE and the Department of Computer Science. New faculty are eligible for special career start-up arrangements including summer support, equipment, graduate student support and reduced teaching loads to encourage the development of successful research programs. Applications and/or requests for further information should be directed to: Dr. William C. Jennings, Department Head, Electrical, Computer and Systems Engineering, Rensselaer Polytechnic Institute, Troy, NY 12180-3590. Dr. Jennings may be reached by phone at (518) 276-6316 or electronically at jennings@ecse.rpi.edu. Rensselaer is an affirmative action/equal opportunity employer and specifically encourages applications from women and minorities.

Department of Electrical, Computer Engineering invites applications for a position at the Assistant Professor level in a specific area of interest is with an emphasis on computer networks. This new faculty major Engineering Research initiative designed to provide technological leadership in the 21st century. The ECSE Department is the largest academic unit at Rensselaer and has a rich tradition for both research and education. ECSE is seeking to add top quality faculty who bring innovative approaches to modern areas of research and who can effectively participate in a campus-wide educational initiative in Interactive Learning. ECSE has major programs in multimedia communications and signal processing; robotics, intelligent control and manufacturing; integrated electronics and electronics manufacturing; and energy systems which contribute to a dynamic research environment. In addition to the extensive research facilities of the department, there are excellent opportunities for faculty to participate in interdisciplinary research centers including the Center for Image Processing Research, the Center for Integrated Electronics and Electronics Manufacturing, the New York State Center for Composite Materials and Structures. There are also close links between ECSE and the Department of Computer Science. New faculty are eligible for special career start-up arrangements including summer support, equipment, graduate student support and reduced teaching loads to encourage the development of successful research programs. Applications and/or requests for further information should be directed to: Dr. William C. Jennings, Department Head, Electrical, Computer and Systems Engineering, Rensselaer Polytechnic Institute, Troy, NY 12180-3590. Dr. Jennings may be reached by phone at (518) 276-6316 or electronically at jennings@ecse.rpi.edu. Rensselaer is an affirmative action/equal opportunity employer and specifically encourages applications from women and minorities.

Boston University Faculty Position: The Computer Science Department at Boston University's Metropolitan College serves professionals in the Greater Boston area with part-time undergraduate and graduate degree programs. These programs are among the largest of their kind in the Northeast. The department seeks an instructor with a technical interest in Networks and Data Communications, beginning in September, 1995. The faculty member will also be expected to spend a significant amount of time advising prospective and current graduate computer science students. Both academic background and industry experience will be considered. A Master's degree, at minimum, and excellent teaching skills are required. Please send applications, and arrange for three letters of accommodation to

Engineering. The goal is to develop processing technology and equipment capability for the fabrication of advanced submicron device structures. Emphasis is on the development of process module clusters for carrying out multiple process steps in an in-situ environment. A post-doctoral research position is available for qualified applicants. This includes supervising students on single wafer processing using RTCVD, RPECVD, RT selective epitaxy and plasma etching. An earned doctorate or equivalent industrial research experience is required. Interested applicants should send resumes and the names, addresses and telephone numbers of three references by April 30, 1995, to: Dr. J.R. Hauser, Center for Advanced Electronic Materials Processing, North Carolina State University, Box 7920, Raleigh, North Carolina 27695. North Carolina State University is an Affirmative Action, Equal Opportunity Employer.

Dean, Erik Jonsson School of Engineering and Computer Science: The University of Texas at Dallas invites nominations and applications for appointment to the position of Dean of the Erik Jonsson School of Engineering and Computer Science and concurrent appointment to the Lars Magnus Ericsson Chair in Electrical Engineering. The University, a Carnegie Foundation "Doctoral University I," emphasizes internationally competitive research by its faculty, selective student admissions, a rigorous curriculum, and a high level of interaction with and service to the multinational technologically sophisticated and managerially intensive businesses and industries headquartered in the region. With a current enrollment of approximately 4500 undergraduates and 4000 graduate students, U.T. Dallas is situated on a spacious 500 acre campus 20 miles north of the central Dallas business district, in the heart of the "Telecom Corridor" complex of residential suburbs and corporate office parks. The Erik Jonsson School offers doctoral and bachelor degrees in Electrical Engineering and in Computer Science, together with masters degrees in those fields and in Engineering Science. Approx-

Post Office
Will Not
Deliver Mail
Without Proper
Postage



IEEE SERVICE CENTER
ATTN: CUSTOMER SERVICE OPERATIONS
445 HOES LANE
PO Box 1331
PISCATAWAY NJ 08855-1331



mately 30 tenured/tenure-track faculty, with strong support from full-time and part-time lecturers, provide instruction in the School's programs, which each award approximately 50 bachelors and 50 masters degrees annually, together with several doctoral degrees. The Dean is the administrative and academic leader of the School, having broad responsibilities for academic policies and procedures, curriculum development, budget management, long-range planning, and the recruitment, development and retention of an outstanding and collegial faculty. The Dean represents the School internally and externally and provides the initiative and leadership for continued development of the strong, synergistic collaborations with individuals and organizations from the high-technology business sector which are a defining feature of the U.T. Dallas mission. The Dean must have outstanding abilities in communication and leadership, as demonstrated in significant administrative positions; must have a record of accomplishment appropriate for a tenured full professorship in the School of Engineering and Computer Science; must have demonstrated commitment to equity and diversity, and the commitment to and enthusiasm for leading the School to even greater levels of productivity and achievement in education and research and for enhancing contributions of the School to the continued technological and economic development of the region and the nation. Applications should include a statement of interest, a full professional resume, and the names, addresses and telephone numbers of at least three references and should be addressed to: Office of the Provost, Att: Abby Kratz, The University of Texas at Dallas, P.O. Box 830688 MS-AD23, Richardson, Texas 75083-0688. Review of applications will begin on February 27, 1995 and continue until the position is filled. The University of Texas at Dallas is an Equal Opportunity, Affirmative Action employer and strongly encourages applications from candidates who would enhance the diversity of the University's faculty and administration.

University of Pittsburgh: The Department of Electrical Engineering invites applicants for a full-time tenure track faculty position at the Assistant or Associate Professor level beginning September 1995. The areas of interest are Computer Engineering and Control. Preference will be given to applicants with research expertise in Computer Architecture, Parallel Processing, Computer Vision, Computer Control, Sensors/Actuators; particularly those with applications in Bioengineering or Manufacturing. Candidates must possess an earned PhD degree and be committed to an integrated program of teaching and research. The department consists of 31 faculty supervising 300 undergraduate and 180 graduate students. Applicants should submit a resume, a brief statement of research and teaching interests and the names of five references to: Dr. Marwan Simaan, Chairman, Department of Electrical Engineering, 348 Benedum Hall, University of Pittsburgh, Pittsburgh, PA 15261. Tel: (412) 624-8002. In order to receive full consideration, applications must be received before April 15, 1995. The University of Pittsburgh is an Affirmative Action/Equal Opportunity Employer.

Electronics Engineering Technology: Tenure leading position at the Assistant Professor level in a TAC-ABET accredited Electronics Engineering Technology program at the Omaha campus of the University of Nebraska/Lincoln. The EET program is in the process of being converted into an Electronics Engineering program. Qualifications: Requires earned Ph.D. in

Electrical Engineering, Computer Engineering, or closely allied field. Must have demonstrated evidence of research and scholarly activity. Relevant industrial experience desirable. Experience in telecommunications, digital signal processing, or computer architecture desirable. Duties may include teaching graduate and undergraduate Electrical Engineering courses. Review of applicants will commence May 15, 1995, and continue until a suitable candidate is found. Send resumes to Prof. Roger D. Sash, Electronics Engineering Technology, Omaha Campus - University of Nebraska, Omaha, NE 68182-0181. The University of Nebraska-Lincoln is committed to a pluralistic campus community through Affirmative Action and Equal Opportunity and is responsive to the needs of dual career couples. We assure reasonable accommodation under the Americans with Disabilities Act; contact Prof. Sash for more information.

Research Fellow - MR Software: The Department of Radiology, University of Minnesota Medical School is seeking a full-time software engineer to be employed as a Research Fellow at the Center for Magnetic Resonance Research. The responsibilities of the position are: 1) Development and documentation of GUI and processing software for the analysis and display of MR images and spectra, 2) System administration of UNIX workstation/Macintosh network. Applicants must have a MS degree in electrical engineering or computer science, and have had extensive computer programming training. Experience with UNIX workstations, the C/C++ programming language, and X-Windows is necessary. Image and signal processing experience is desirable. Previous experience with magnetic resonance instrumentation and system administration is preferred but not required. Salary will be commensurate with experience. A resume and three letters of recommendation should be sent to: John P. Strupp, Center for Magnetic Resonance Research, University of Minnesota Medical School, 385 East River Road, Minneapolis, MN 55455. Deadline for receipt of applications is March 31, 1995. The University of Minnesota is an equal opportunity educator and employer.

University of Massachusetts, Department of Electrical and Computer Engineering: The Department of Electrical and Computer Engineering at the University of Massachusetts at Amherst invites applications for a tenure-track position in electrical and computer engineering as an associate or full professor. We are seeking candidates in the following areas: (1) wireless telecommunication networks, (2) semiconductor (e.g., VLSI ICs, MCMs) manufacturing, and (3) optical remote sensing. Rank and salary will be commensurate with qualifications. Applicants must have an earned doctorate and a proven record of research funding. Preference will be given to candidates with experimental/industrial experience. The search will continue until the position is filled. Send a resume and names of at least three references to Chair, Search Committee, Department of Electrical and Computer Engineering, University of Massachusetts, Amherst, MA 01003. The University of Massachusetts is an Affirmative Action/Equal Opportunity employer.

Montana Tech's Department of Engineering Science invites applications for the position of Assistant Professor of Engineering Science beginning August 1995. A Ph.D. (M.S. acceptable if accompanied by extensive industrial experience) in Electrical Engineering, Systems Control Engineering, or related field is

CLASSIFIED EMPLOYMENT OPPORTUNITIES

required. Teaching and industrial experience are desirable but not required. Duties include teaching courses and associated laboratories offered in the Engineering Science - Systems/Control concentration (instrumentation, circuits, power and machinery, control theory, DSP and digital electronics.) Screening of applications will start April 17, 1995 and continue until the position is filled. Salary and benefits are competitive. Send letter of application, resume, and names of three references to Dr. Lindsay Hess, Head, Department of Engineering Science, Montana Tech, 1300 West Park Street, Butte, MT 59701-8997. EEO/AEE

Assistant Research Engineer, University of California, Berkeley: Department of Materials Science and Engineering. Duties include the development of microfabrication processes for microcapsules and microfilters, and assistance in the coordination of students doing research related to the project. Requirements: PhD in Electrical Engineering or related fields and prior experience in microfabrication, with preference to MEMS. Salary range: \$54,300-\$68,800, depending on qualifications. Initial appointment for 17 months, starting as soon as possible. Reappointment subject to the availability of extramural funds. Application deadline: April 15, 1995. Send CV and three references to: Prof. Mauro Ferrari, 733 Davis Hall, University of California, Berkeley 94720.

The University of Newcastle (Australia) Department of Electrical and Computer Engineering seeks applicants for a fixed-term appointment (initially 3 years) as Lecturer/Senior Lecturer to teach courses up to post-graduate level in the general area of Electric Power Engineering and conduct research (including the supervision of post-graduate students), in one aspect of Power Plant Engineering, provide research leadership in Power Plant Engineering and develop strong industrial links. Selection criteria essential - PhD in Electric Power Engineering, teaching experience and appropriate industrial experience in Power Engineering. Desirable - skills in the area of life assessment of Power Plant and proven research skills in the area of insulation testing. Salary - Senior Lecturer \$A50,928 - \$A58,724 per annum Lecturer \$A41,574 - \$A49,370 per annum. For appropriate candidate, significant consultative opportunities exist with the industrial sponsor - Pacific Power. For further information and copy of full advertisement contact Associate Professor R. Middleton, 6149 216033 or Professor G. Ledwich, 6149 216083, email eegl@ee.newcastle.edu.au. Applications close 28 April 1995.

Harvard University: We invite applications from candidates at all levels for a faculty position in Electrical Engineering. Individuals with interests in the area of electronics or communications are sought. Candidates should have an interest in design and fabrication at the device or systems level and have a Ph.D. in Electrical Engineering, Computer Engineering, or a related discipline. Responsibilities include teaching in the AB., S.B., and Ph.D. programs and having a strong research commitment. Applicants should submit a curriculum vitae and the names, addresses (including email) and telephone numbers of three references to the EE Search Committee, Pierce Hall 217, Harvard University, 29 Oxford Street, Cambridge, MA 02138. Applications should be received by April 30, 1995. Harvard is an Equal

CLASSIFIED EMPLOYMENT OPPORTUNITIES

Opportunity/Affirmative Action employer and encourages applications from women and members of minority groups.

The Department of Electrical Engineering, University of Pennsylvania, is inviting applications for one faculty position in the area of Modern Digital Signal Processing and Communications. The appointment will likely be at the assistant professor level, although exceptionally qualified applicants may be considered for other levels. Candidates with expertise in one or more of the following or closely related areas of research interest are invited to apply for this position: video processing, coding and transmission; signal processing theory, architectures, implementations, and applications; wireless communications. The successful applicant will be able to teach a range of courses at both the undergraduate and graduate levels, will have an excellent record of research accomplishments and will engage in funded research projects in cutting-edge areas in signal processing. Applicants are invited to send a complete resume with names of at least three references to: Chairman, Department of Electrical Engineering, Moore School, University of Pennsylvania, Philadelphia, PA 19104. Applications arriving after April 1, 1995 are not assured of receiving consideration.

Industrial Technology Instructor: Qualifications - 2000 hours work experience in industry, prefer recent experience. Teaching experience preferred. Bachelor's required, Master's preferred. Send letter, resume, & college transcripts by 4/14/95 to: Duane K. Kessler, Kaskaskia College, 27210 College Road, Centralia, IL 62801.

Associate Scientist - Center for Nondestructive Evaluation, Iowa State University: The Center for Nondestructive Evaluation at Iowa State University is seeking an Associate Scientist to develop and implement a research program applying signal and image processing techniques to x-ray and other nondestructive evaluation methods. Position requires a Ph.D. in electrical engineering or related field with two years of related research experience (may be concurrent with pursuit of degree). Experience must include x-ray image processing techniques, i.e., POD, image digitization and enhancement. Salary of \$37,422 minimum, plus benefits. Send cover letter, resume, plus the names and addresses of three references to: Ames Laboratory/IPRT Personnel Office, 105 TASF, Iowa State University, Ames, IA 50011. Application deadline of April 15, 1995. An EEO/AA employer.

BellSouth Eminent Scholar's Chair in Computer Engineering and Communications: The Department of Electrical Engineering at the University of Florida invites nominations and applications for an endowed, chaired professorship in the general field of computers and communications. The Department of Electrical Engineering is the largest department in the University of Florida with about 425 undergraduates (junior and senior year only) and about 325 graduate students. The department is ranked 22 from about 260 Electrical Engineering undergraduate programs. There are eleven IEEE Fellows and two members of the National Academy of Engineering on the Electrical Engineering Faculty. There is presently one Eminent Scholar who holds the endowed chair in Microelectronics. For the BellSouth Chair we seek a

researcher and teacher of great distinction. Proceeds from an endowment and additional resources will provide an environment commensurate with the excellence of the person sought. Nominations and applications should be sent to Professor Stanley Su, who co-chairs the BellSouth Chair Search Committee, Department of Electrical Engineering, 470 CSE, University of Florida, Gainesville, FL 32611-6125. Telephone 904/392-2693 or 904/392-2680; Fax 904/392-0044; email su@cis.ufl.edu. The application deadline is June 1, 1995. The University of Florida is an Affirmative Action Employer, and women and minorities are encouraged to apply. According to Florida law, applications and meetings regarding applications are open to the public upon request.

Government/Industry Positions Open

Project Electrical Engineer Wanted - Must have 5+ years exp. in design with Consulting Firm. Mail resume to: J.E. Connelly - CS Associates-P.O. Box 30926-Tucson, AZ 85751-0926. 602-327-7999

Senior Research Engineer: 40 Hours/week; 8:00 a.m. - 5:00 p.m.; \$63,600/year. Job requires ■ Ph.D. in Electrical Engineering and 18 months experience in Job Offered or as Controls Engineer. Job also requires: 1) Ph.D. dissertation in the area of adaptive control; 2) 2 journal publications in the area of adaptive control; 3) 1 journal publication in the area of digital signal processing; 4) Experience must include experience developing and implementing real-time engine controls; 5) Experience must include experience using computer-aided control systems design software; and 6) Experience must include experience designing and analyzing electronic engine control and diagnostics algorithms. Any experience requirements may be met concurrently during the same 18 month period. Job duties: Conduct research in automotive engine controls. Develop concepts and evaluate model-based adaptive algorithms for transient air-fuel ratio control and powertrain diagnostics. Recommend and initiate research and development plans on projects related to engine controls and diagnostics. Communicate research results effectively both orally and in writing to managers, researchers, and divisional customers. Interact closely with divisional customers and partners to meet project objects. Develop dynamic powertrain models for control systems analysis and design. Qualified applicants should send resume and verification of requirements to: 7310 Woodward, Room 415, Detroit, MI 48202. Reference #17795. Employer paid advertisement. An equal opportunity employer.

Engineer, Senior: Develop high efficiency cellular transmission methods for digital signals, analyze and simulate high spectral efficiency modulation and coding techniques in the cellular environment. Min. Ph.D. (Electrical Engineering) plus 1 yr. exp. or M.Sc. (Electrical Engineering) plus 5 yrs. exp. Requirements: Background in communication theory/adaptive signal processing/cellular networks. In-depth understanding of modulation and coding requirements for fading terrestrial channels. Job site/interview: San Diego, CA. Salary: \$62,000/yr. 40 hrs/wk. Send this ad and your resume to Job #MLM 15957, P.O. Box 290605, Sacramento, CA 95826-9605.

Senior Design Engineer: Battery Industry. Western Regional battery and custom plastics mfr. announces a need for an advanced technical

specialist with significant industry experience. Responsibilities include: Plan and execute new product devt of custom and smart battery packs. Develop capability to design, develop and manufacture battery chargers. Requirements: Tech degree, preferably advanced, 10-15 years product devt and/or project mgt and/or applications engrg experience in battery packs, smart packs and/or battery chargers; AutoCAD 12.0 proficiency. Preferences: experience in DFM&A, FMEA, GD&T, SPC and DOE; known professional standing in the battery/battery pack industry (i.e., patents, articles, etc.); second language, preferably Pacific Rim. Excellent opportunity to play a critical role with a rapidly growing company. Job location: Portland, Oregon metro area. Send resume to: Engineering Manager, P.O. Box 584, Beaverton, OR 97075.

Software Engineer needed to write, design and implement software for mortgage lending industry using all functions of the Borland C++ Version 3 professional software package, Make and Polytron's PVCS, as well as third party libraries for specific functions. Perform system builds specializing in data communications and financial calculations. Responsible for supervision of 2 - 4 software engineers. Must have: Bachelor's Degree in Computer Science and 1 year experience writing financial software, including methodology research, implementation, testing and documentation of financial software systems using all functions of the Borland C++ Version 3 professional software package, Make, and Polytron's PVCS. Must also have Bachelor's Degree in Business Administration with emphasis on finance or 2 years experience working with the mortgage loan industry. Experience may be gained concurrently. Salary: \$42,000/year; 40 hours/week in Kirkland, WA. Send resume by 3/31/95 to: Job Order #471733; Employment Security Dept., E&T Div., PO Box 9046, Olympia, WA 98507-9046.

Engineering Business Consultant: Sprrt autmtn projs at cust sites & meet integtrn/autmtn proj sched reqs, prepare & review funclnl specs, matls (trng manls, instl manls, etc), desgn docs & test plans. Code enhancements, correct prblms while wrkg in C, TCP/IP, & SQL in VMS environ, provide timely & relevant status reports of projs to mgmt, ensure accuracy & qty of all user deliverables, coordinate activities between cust & vendors. Min 40/wk. \$45,000/year. Reqs: M.S. in Industrial Engineering with specialization in Mfg. & Automation & 2 yrs. exp. in job offered or 2 yrs exp working with process control system in mfg. envrnment. Spec. Reqs: 2 yrs prior exp must incl 1 yr tstng & validation of factory automation systems including Automated Material Handling Systems. Proficiency in writing SW in "C" & Pascal langs in VMS mfg. envrnmt; knwldg of prgrmmng SQL and TCP/IP protocols in VMS mfg. envrnmt; exp in devlpmnt & writing of intrnl techncl manls and specs.; willing to relocate and able to travel for extended periods of time. Job in Rio Rancho, NM. Qualfd aplcmts send res to: NM Dept of Labor, P.O. Box 44276, Rio Rancho, NM 87174, Job Order No. 426503. Must have proof of legal auth to wrk in US. The comp is an Equal Opp employer & fully supports affirmative action practices.

Engineering Opportunities: GSE, Inc., a prominent electronics manufacturing company, is seeking several highly motivated individuals to assist in developing new product markets and product lines. Due to significant growth and establishment of the market potentials, we are now accepting applications for several posi-

tions in the Development Engineering and Test Engineering areas. Senior Project Engineers - We are seeking individuals to manage the development of several new product lines. Candidates must be capable of managing a small group of electrical and mechanical design engineers toward the development of microprocessor based smart transducers. Individuals must possess the following qualifications: Minimum of a Bachelor of Science Degree in Mechanical or Electrical Engineering with five to ten years experience and project management. Must be capable of developing new product specifications through interaction with end users and marketing contacts. Products developed will include microprocessors, strain gages, finite element analysis on metal transducer flexures, laser gyro, infra-red and radio frequency communications. Hardware/Software Engineers - GSE needs several Electrical Engineers capable of designing microprocessor hardware and software. Minimum of BSEE and BSEET with three years or more experience. Familiar with C, C++, Motorola and Intel processors, ACAD and Integraph. Transducer Design Engineers - GSE now has openings in strain gage transducer design. We are seeking an individual to develop flexure design, execute 3-D finite element analysis, and assist in developing test fixtures and calibration procedures. Minimum of BSME or BSMET with three years or more experience. Familiar with ACAD12 (3-D), Algor (with Hexagon), DOS, Windows, etc. A strong electrical background is preferred. We offer a competitive compensation package and an exciting growth environment for the right people. Please send your resume in confidence to: GSE, Inc., 23640 Research Drive, Farmington Hills, MI 48335-2621, Attention: Human Resources/EE.

Electronics Design Engineer for Dayton Area Equipment Mfr. Duties include development of software and hardware protocols for image processing systems used in electronic engraving system, analysis of user requirements to develop graphics user interfaces for cylinder composition software system, development of automatic manufacturing control algorithm for engraving procedure assisted by image processing system, and performance of concurrent programming in "C" language with following interprocess protocols. Position is also responsible for providing technical support for Chinese-speaking companies in the areas of installing and upgrading software, training users, and performing ongoing technical support and trouble shooting. Position requires travel to Asia for one-to-two week periods about three or four times per year. Requirements for this position include a Masters Degree in Mechanical or Electrical Engineering, the curriculum of which included courses in Digital Image Processing, Microcomputer Applications, Comp I/O Realtime, Advanced Computer Vision, Computer Communication Networks, and System Dynamic Analysis. The Master thesis must be in a topic related to Image Processing. Position also requires the ability to read, write and speak Chinese. No experience required. Hours are usually 8 a.m. to 5 p.m. Monday thru Friday (40 hours per week) with some overtime as required by project deadlines or customer demands. Rate of pay is \$37,500 per year with no additional overtime compensation. Send two (2) resumes and cover letters (no calls) to: G. Maugans, JOB# 00823, Ohio Bureau of Employment Services, PO Box 1618, Columbus, OH 43216.

Senior Engineer/Architect (Electrical), Denver International Airport: The City & County of

Denver is seeking qualified candidates to fill the position of Senior Engineer/Architect (Electrical) at Denver International Airport. Candidates must have a minimum of 3 years experience as an Electrical Engineer with qualifications in Engineering Planning, Design, Construction, Operation & Maintenance of large complex electrical/power systems in multi buildings and systems. Experience should include the following applications; Lighting Controls, Low & Medium Voltage Distribution, Low & High Voltage Systems in large physical plants, Conventional Buildings Systems, Energy Management, Life Safety Systems, and Distributed Control Systems. Full knowledge of the National Electrical Code. Computer literacy in the following desirable; Computer/PLC Control Networks, Microsoft Windows, MMI Software Packages, WordPerfect & Lotus. Must have understanding of other engineering disciplines and architecture as well as have a good working relationship with other engineering disciplines and construction trades. This position will function as the only Electrical Engineer in the Planning and Engineering Division of DIA. Airport facilities experience is preferred, but not required. Must have a Baccalaureate Degree with major course work in Electrical Engineering. Registration as a P.E. by the Colorado State Board of Registration for Professional Engineers at the time of application. Registration as a P.E. by another state will be accepted in lieu of this requirement, provided that the applicant must be registered by the State of Colorado by completion of the probationary period. If you meet the education and experience requirements please apply with the City & County of Denver, Career Service Authority, 110 - 16th Street, Denver, CO 80202. The City & County of Denver has a residency rule that requires all employees to reside within the boundaries of the City & County of Denver within 90 days of the standard 6 month probationary period completion. The City & County of Denver is an Equal Opportunity/Affirmative Action Employer.

Electrical Engineer - responsible for the company's hardware and software department. Testing and design of power sources. Testing and design of computer circuits. Assembling and testing of personal computers. Testing and design of telecommunication computers. Interfacing personal computers with telecommunication computers. 8:30 am - 5:30 pm. 40 hrs/wk. \$33,060 per annum. Require BS in Electrical Engineering and one year's exp in the job offered or one year exp as Laboratory Assistant, Laboratory Manager or Equivalent. Exp to include: research and development in computer architecture, including Cmos Logic, TTL Logic, ECL Logic and design of interface hardware; programming of high speed integrated circuits; design and implementation of digital, telecommunication and power circuits; and design and implementation of high frequency Analog AC, DC converters. Exp may be gained before, during or after degree. Send 2 resumes and cover letters (no calls) to: J. Davies, JOB# 00906, Ohio Bureau of Employment Services, PO Box 1618, Columbus, OH 43216.

Computer Software Engineer for communications software development for complex real-time security accounting management systems w/emphasis on applications development in C on UNIX & VAX/VMS platforms, serial communications, networking, and structured analysis & design for transaction processing systems. Work w/ min. supervision to design, develop, code, test & implement simulator software & systems on DOS. Develop system &

CLASSIFIED EMPLOYMENT OPPORTUNITIES

software specs as well as user documentation. Write program & operation documentation & reports. Participate in Request for Proposal studies. Conduct research on relevant applications of current hardware & software tools. Requires B.S. or foreign equiv in Computer Science or related major & 1 year experience in job offered or in real-time software development capacity. Must have prior practical application of the following knowledge in a real-time environment: C language; VAX/VMS, UNIX & DOS platforms; serial communications; structured analysis & design; TCP/IP network protocols; &, either UNIX IPC, CASE tools, or internals & device drivers. Must be eligible to obtain NV gaming card & passport. Job site: Reno, NV. Yrly salary: \$36,600. 40 hr. work week. Successful candidate must prove legal right to work permanently in the U.S. Submit resume & copy of ad to #9428893, Nevada Employment Security Division, 70 W. Taylor St., Reno, NV 89509-1700.

Senior Design Engineer: Design and development of electronic ballast for lighting industry. Project management responsibility for the specific product to be introduced. Includes product, introduction process and conception through transition to manufacturing and designing multistage power supplies for fluorescent and other types of lamp applications. Advanced electronic group research and development of new concepts, more efficient circuits/concepts for electronic ballast. \$53,000/yr. Reqs. BS Electrical Engr' & 5 yrs. exp. in job. Send resume & Soc. Security # to the Indiana Department of Workforce Development, 10 N. Senate Ave., Indianapolis, IN 46204-2277, Attn: Mr. Gene Replogle. ID# 3379417

Opto-Mechanical Packaging Engineer to lead development of optoelectronic devices for commercial products. Requires 5+ yrs. commercial experience with semiconductor optoelectronics packaging, design and processing. B.S. or M.S. in mechanical engineering or related field, with expertise in mechanics, micromechanical components, optics and materials. Submit resumes to Human Resources, Dept. 95-PKG, 2330 Faraday Ave., Carlsbad, CA 92008. EOE M/F/D/V

Scientist/Engineer - Solid-State Power Device - Cree Research, Inc. is the world leader in silicon carbide semiconductor device technology. The continued growth of our Research Triangle Park, N.C. facility has created an opening for a Solid-State Power Device Scientist/Engineer to perform silicon carbide device R&D. This position requires experience in the design and fabrication of high voltage, silicon power MOSFETs. An advanced degree and experience with MOS device modeling, device processing and other power device (e.g. thyristor, rectifier, BJT, IGBT) are desired. We offer a competitive salary and excellent benefits package. Please submit resume, including salary requirements, to: Human Resources, Cree Research, Inc., 2810 Meridian Parkway, Suite 176, Durham, NC 27713. EOE/AA Employer

Engineering Opportunity: Aeroquip Corporation is currently seeking an Electrical Engineer for our Corporate Technology Lab located in Ann Arbor, MI. Aeroquip Corporation, a TRINOVA company, is a world leader in the manufacture and distribution of engineered components and systems for industry. The Corporate Technol-

WHAT DO 320,000 ELECTRICAL ENGINEERING, ELECTRONICS & COMPUTING PROFESSIONALS HAVE IN COMMON? The Institute of Electrical and Electronics Engineers

JOIN TODAY AND ENHANCE YOUR POTENTIAL FOR PROFESSIONAL SUCCESS

STAY CURRENT WITH TODAY'S TECHNOLOGY

IEEE is the largest publisher of technical information in the field.....all available at low member prices

ENHANCE YOUR CAREER BY NETWORKING

IEEE conducts more than 300 major conferences and 5,000 local meetings annually that provide first-hand knowledge of new product developments and access to colleagues on the cutting edge of your technology.

RECEIVE YOUR OWN SUBSCRIPTION TO SPECTRUM

IEEE Spectrum, winner of the prestigious National Magazine Award, delivers the latest technical information in a practical context and reveals the relationship between your career and trends in politics, business, academia and the economy.

PLAN FOR YOUR FINANCIAL FUTURE

IEEE members in the United States can take advantage of financial and investment services like mutual funds, loans, credit cards and insurance...all at prices non-members simply can't get.



IEEE

THE INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC.

CONTACT US NOW FOR AN APPLICATION

Telephone 1-908-981-3080 ♦ 1-800-678-IEEE

E-Mail: member_services@ieee.org ♦ Fax: 1-908-981-9667

CLASSIFIED EMPLOYMENT OPPORTUNITIES

ogy Lab is the center of innovation for the company's New Business Development Organization. Only about a year old, the Lab provides self-starters who are able to balance a variety of simultaneous projects, a unique opportunity to become involved in the development of a dynamic new enterprise. Qualifications for this position include: Advanced degree; Experience in sensors, communication, instrumentation, fiber optics, and circuit design; Experience in electronic product design and lithography preferred; A minimum of 2 years' experience in the electronics industry. To be considered, please send your resume and salary history/requirements to: Aeroquip Corporation, Corporate Technology Lab, Dept. A, 2323 Green Rd., Ann Arbor, MI 48105-1530. All replies will be held in confidence. We are an equal opportunity employer.

Electrical Engineer: A NW OH engineering firm has an opening for an Electrical Engineer to prepare detailed plans and specifications for electrical power distribution systems for hazardous areas. Duties include short circuit and overcurrent protection and calculations, indoor/outdoor illumination for commercial and industrial applications, cost estimates, detailed electrical equipment specifications, National Electrical Code (NEC) and American Disability Act (ADA) compliance reviews, standby emergency equipment and generators, energy management, motor controls, schematic diagrams for control applications, and lightning protection. Must have 3 yrs experience in designing power distribution systems for all the following hazardous locations: 1) wastewater treatment plants; 2) leachate and sewage pumping and storage facilities; 3) solid waste landfills. Education (BSEE) must include one course in each one of the following topics: power systems, logic and switch theory and instrumentation and control design. EOE. 40 hrs/wk - 8am-5pm, Mon-Fri; Salary - \$3,120/month. Send 2 resumes & cover letters (no calls) to: J. Davies, Job #00853, Employment Services, P.O. Box 1618, Columbus, OH 43216.

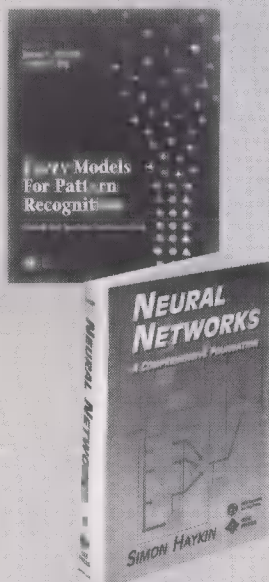
Newly formed company in Atlanta, GA providing proprietary testing services to fabricators and assemblers in the electronic packaging industry requires a Manager having 5+ years experience in electronics manufacturing industry. Must have: successful sales & manufacturing involvement, versatility, significant contacts. Reply in confidence to IEEE Spectrum, Box 3-1, 345 E. 47th St., New York, NY 10017.

Director of Engineering: We are a leading manufacturer of frequency control devices with a worldwide reputation and marketing for quality and design, which has an immediate requirement for a highly motivated engineer. Qualified candidates should have 10+ years related experience, preferably in both the crystal and oscillator areas along with an EE degree. Prior managerial experience a plus. Competitive salary and excellent benefit package commensurate with this high profile position; reporting to the President. Excellent family oriented northeastern location with a climate offering something for every kind of outdoor enthusiast. Submit detailed resume of educational background, work and salary history, and references to: Bliley Electric Company, Attn: Richard D. Bliley, President, P.O. Box 3428, Erie, PA 16508. EOE M/F

NEW... FROM THE IEEE



PUBLICATIONS IN
FUZZY LOGIC
FROM THE
WORLD'S MOST
COMPREHENSIVE
PUBLISHER IN
ELECTRICAL,
ELECTRONICS,
AND COMPUTING
ENGINEERING



FUZZY MODELS FOR PATTERN RECOGNITION

Methods That Search for Structures in Data

edited by James C. Bezdek, University of West Florida,
and Sankar K. Pal, NASA Johnson Space Center

Beginning with Lotfi Zadeh's original 1965 article on fuzzy sets, the editors of this important new book take you chronologically through categories on the evolution of fuzzy algorithms for feature analysis, clustering and classifier design, and image processing and vision. Each category is divided into topics which the world's leading researchers on the subject discuss everything from theory to the practical application of a pattern recognition system in a design problem.

"...one of the best written, concise discussions of fuzzy set theory and its applications to pattern recognition that I have ever seen."

— Frederick E. Petry,
Tulane University.

IEEE Member Price: \$60.00

List Price: \$74.95

1992 Hardcover 552pp

IEEE Order No. PC3178

ISBN 0-7803-0422-5

NEURAL NETWORKS

A Comprehensive Foundation

by Simon Haykin,

McMaster University Communications Research Library

Co-published with Macmillan and IEEE Computer Society Press

Written from an engineering perspective, NEURAL NETWORKS provides a comprehensive, up-to-the-minute treatment of the field, complete with incisive examples, challenging problems and computer-oriented experiments. The material is presented in a clear and easy-to-understand style, with derivations as complete and simple as possible. It introduces common models and algorithms in a thorough and straightforward manner and is filled with examples so that readers can see real applications of neural networks.

"The best engineering-based text by a considerable margin..."

— James A. Anderson,
Brown University

**For IEEE
Members Only!**

IEEE Member Price: \$56.00

List Price: \$69.95

1994 Hardcover 720pp

IEEE Order No. PC4036

ISBN 0-02-352761-7

ALSO AVAILABLE. EXCITING VIDEO TAPES ON FUZZY LOGIC!

FUZZY LOGIC

Advanced Concepts & Structures

presented by Lotfi Zadeh, Electrical Engineering
Department, University of California at Berkeley

Have you always wanted to know the ideas underlying fuzzy logic? Now, the "inventor" of fuzzy logic, Lotfi Zadeh, has prepared this course specifically to teach you the concepts and structures underlying fuzzy logic.

IEEE Member Price: \$89.95

List Price: \$129.00

1992 2 hours 1 VHS tape

IEEE Order No. HV2584 (NTSC)

ISBN 0-7803-0333-4 (NTSC)

INTRODUCTION TO FUZZY SET THEORY AND FUZZY LOGIC

Basic Concepts and Structures

presented by Enrique Ruspini,
Artificial Intelligence Center, SRI Intelligence

Learn how to use the basic tools, concepts and structures of fuzzy sets and fuzzy theory. This video will help you understand the nature and characteristics of fuzzy logic and applications.

IEEE Member Price: \$89.95

List Price: \$129.00

1992 2 hours 1 VHS tape

IEEE Order No. HV2576 (NTSC)

ISBN 0-7803-0332-6 (NTSC)

FUZZY LOGIC

Technology and Applications

The one, current source for the
newest applications in fuzzy logic!

This 1994 volume details the recent advances in the design, applications, and foundations of fuzzy logic. This volume is the key source where a professional entering or working in the field of fuzzy logic can find the best practical papers.

IEEE Member Price: \$48.00

List Price: \$59.95

1994 Hardcover 470pp

IEEE Order No. CR1016

ISBN 0-7803-1383-6

FOR FASTEST SERVICE, CALL 1-800-678-IEEE (1-908-981-0060 OUTSIDE OF THE U.S.) OR FAX: 1-908-981-9667

The Institute of Electrical and Electronics Engineers, Inc. • 445 Hoes Lane • Piscataway, NJ 08855-1331 USA

ADVERTISING RATES

12 insertions—\$4200 1 insertion—\$350
50% discount to IEEE members on three or more insertions.
If you are an IEEE member, please enclose your membership number with the order.
Copy cannot exceed 1-inch in depth. No product may be offered for sale. Advertising restricted to professional engineering and consulting services. No orders can be accepted by telephone, order and copy must be sent together.

For any further information and closing dates please contact
Advertising Production, 908-562-6334

IOCC INTEGRATED OPTICAL CIRCUIT CONSULTANTS

Consulting, Contract R&D, and Prototyping
Integrated, Fiber, and Guided-Wave Optics
• Applications Engineering
• Design, Fabrication and Evaluation
• Critical Analysis of Technology
• Troubleshooting
• Marketing

R.A. Becker, D. Sc.
President
(408) 446-9812

10482 Chisholm Ave.
Cupertino, CA 95014

KIERNAN ENGINEERING

Electrical, Electronic, and Electro-mechanical Parts Engineering

Parts Selection and Documentation
Program Parts List Preparation and Review
Parts Control Program Documentation

Gerard F. Kiernan, P.E.
5309 Riverdale Road, Ste. 725
Riverdale, MD 20737

Tel: 301-779-7073
Fax: 301-779-7162

THE CONSULTING GROUP

- Microwave, ARF, Circuit and Systems Design
- Oscillators, Amplifiers, Filters, Antennas, Synthesizer/PLL Design, Microprocessor, Communication ckt's.
- R&D, Prototyping & Testing in our Lab facilities.

119-40 Metropolitan Ave., Ste. A2, Kew Gardens, NY 11415
Ph. (718) 846-5400 Fax (718) 846-2440

SYNCHRO DESIGN Inc.

DESIGN OF MIXED-SIGNAL INTEGRATED CIRCUITS
ENGINEERING SYSTEM INTERFACE THROUGH SILICON
SPECIALIZING IN HIGH DYNAMIC-RANGE APPLICATIONS
• ANALOG-TO-DIGITAL AND DIGITAL-TO-ANALOG CONVERTERS
• SWITCHED-CAPACITOR FILTERS
• BUFFER AMPLIFIERS
• LOW-VOLTAGE ANALOG-CMOS CIRCUITS
• PHASE-LOCK LOOPS
Contact: Daniel Senderowicz, Ph.D.
2140 Shattuck Avenue, Suite 605 Phone: (510) 486-0797
Berkeley, California 94704-1210 E-mail: daniel@synchrods.com

ANTENNAS for WIRELESS PRODUCTS INTEGRATED and MINIATURE ANTENNAS DSP and LOW COST DSP ALTERNATIVES



Steven L. Myers, Ph.D., P.E.
President

MYERS ENGINEERING INTERNATIONAL, INC.

POB 15908, Ft. Lauderdale, FL 33318-5908, USA
Tel 305-345-5000 Fax 305-345-5005

RAINES ELECTROMAGNETICS Consulting Since 1972

- On Site Measurements of Electric and Magnetic Fields
 - Design, Analysis, and Numerical Simulation of Electromagnetic Radiating and Scattering Systems.
- Applications to Telecommunications, Radar, Radio & Television Broadcasting, Power Lines, and Architectural Shielding.

Jeremy K. Raines, Ph.D., P.E.

(301) 279-2972

CONSULTING & PROTOTYPES ELECTRIC MOTORS

BRUSHLESS MOTORS SWITCHED RELUCTANCE
STEPPING MOTORS AC INDUCTION

MAGNA PHYSICS
100 Homestead Ave.
HILLSBORO, OH 45133

JAMES R. HENDERSHOT
TEL: 513-393-9835
FAX: 513-393-9836



JSNR Semiconductors Inc.
Mixed-Signal ICs and EDA Tools

- Multimedia CODECs • Modem Front-Ends • Video Converters •
- High Resolution Delta-Sigma Audio • High Speed Digitizers •
- Over 10 years experience designing parts for production
- Switched-Capacitor, Continuous-Time and Digital Filters •
- Interpolation and Decimation • High Performance Analog CMOS •
- Complete top-down capability: architecture, design, and layout

P.O. Box 43206
Austin, TX 78745-0206

Tel: (512) 329-8446
Email: info@snr.com

CONTROL SYSTEM CONSULTING

- Servo design, high performance motion control, synthesis, system performance, simulation, specs, integration, testing
 - Electrical, mechanical, hydraulic
 - Defense, aerospace, industrial experience
- 30 East Gate Road A.R. Hazelton
Danbury, Conn. 06811 (203) 743-7002

Patent Attorney

Robert E. Malm, Ph.D. (M.I.T.)
Attorney At Law

Post Office Box 522
Pacific Palisades, CA 90272
Tel: (310) 459-8728
Fax: (310) 573-1781

Structural Methods • Simulation
System Development • Analysis

H&A System Engineering

Kip Haggerty, PhD, PE
Leslie Haggerty

P.O. Box 727
Lawndale, CA 90260
Tel: (310) 679-2440
Fax: (310) 679-9667

email: pp002322@interramp.com

IRA J. PITEL, Ph.D.

Consulting, Research and Development
in Power Electronics and Magnetics
Power Supplies, Inverters, Converters, Motor
Drives, Lighting Controls, Industrial Controls,
Transformers, and Special Magnetics.

MAGNA-POWER ELECTRONICS, INC.
85 Fulton Street Boonton, NJ 07005
(201) 263-0017 Fax (201) 263-1928

PATENT ATTORNEY OF JAPAN TAKADA & ASSOCIATES

Specialty: electrical, electronic, computer,
telecommunications, mechanical,
trademark, and servicemark cases
Hanabusa Bldg., 12-6 Minamioyama 5-chome
Minato-ku, TOKYO, JAPAN
Fax: (03) 5485-9147 Phone: (03) 5485-9146

POWER SUPPLY EXPERTISE Consulting Since 1977

from concept to prototype;
have laboratory; will travel

- ☐ switchmode ☐ EMI
- ☐ quasi-resonant ☐ magnetics
- ☐ telecom power ☐ mag. amps

William F. Slack, President
Sussex Technical Corp.
(214) 495-9293

6114 Turnberry Drive
Garland, Texas 75044
fax 214/495-6434

LEONARD R. KAHN, P.E.

Consultant in Communications and Electronics
Single Sideband and Frequency Shift Systems
Diversity Reception - Stereophonic Systems
Modulation Systems
Registered Patent Agent

222 Westbury Ave.
Carle Place, NY 11514
516-222-2221

PATENT SERVICES

computer and electronic arts

Philip O. Post

Patent, Trademark and Copyright Law

Phone: (800) 435-0353

FAX: (609) 667-7673

call for brochure of services

INNOVATIVE ENGINEERING

Consulting since 1984. Fully equipped lab.

Complete service from concept to prototype.

- *Digital & Analog circuits and systems design.
- *High speed, clock rate/BW to 500 MHz.
- *PLL, NCO, Synthesizers, Filters, A/D Conversion.
- *DSP, Microcontrollers, Embedded control.

Phone: (818) 716-5728 Fax: (818) 716-5726

Imaging & Measurement

Design, Prototyping, Contract Manufacturing
20+ years of sensing, imaging, measurement and
microprocessing experience solves
problems & gets you to market faster.



WINTRISS
ENGINEERING
CORPORATION

Call 800-550-7301
for details.



TALBOT TECHNOLOGY CORP.
Dan Talbot
President

CONSULTING IN:

- ELECTRONICS FOR FIBEROPTICS
- ANALOG/RF/VIDEO/PLL OR DDS FREQ. SYNTHESIS DESIGN
- CUSTOM ANALOG OR MIXED ASIC DESIGN

P.O. Box 151, HUDSON, MA 01749 PHONE: 508-562-5820 FAX: 508-568-1219

MOTOR DESIGN

- DC & AC motors (fractional & multi H.P.) • Computer modelling (F.E.A.) • Prototyping and testing •
- Technical seminars • Motion control • Magnetic devices • Magnet charging • Solenoids • Actuators •

G² CONSULTING

Services since 1987

GEORGE P. GOGUE, Ph.D.
16985 S.W. Kemmer Road, Beaverton, Oregon 97007
Phone: (503) 590-9014 Fax: (503) 590-9015

European Patent Attorney

ing. Umberto MONTI
Via Washington 48
I-20146 Milano Italy

Tel (39.2) 4985057 Fax (39.2) 4817645

Filing & prosecution of European and
national patent applications

MOTION CONTROL SYSTEMS

Analog, Digital, uP Circuits
Motors, Sensors, Drivers
Switchmode Power
DSP, PLL, DAS

Analysis
Simulation
Design
Prototypes

Avens Technology
301 Applebriar Ln.
Marlboro, MA 01752

D.L. Ahonen, President
Ph/FAX: 508-460-6541
E-mail: dila@shore.net

KOTHEIMER ASSOCIATES

Industrial & Power System Consulting

Electromagnetic interference, Transients, Surges, ESD,
RFI, Current transformer transient saturation,
Protective Relays, Electromagnetic fields, Control cable
shielding & grounding, Custom seminars, Technical
auditing, Design, Harmonic analysis, Feasibility studies,
EMC in product design, Trouble shooting

W.C. Kothelmer 5900 NW 99th Avenue
TEL/FAX (305) 345-6378 Parkland, FL 33076-2566

IEEE Presents Its 1995 Plans for Conference Proceedings

THE 1995 IEEE PREPAID ORDER PLAN (POP)

Subscribe to the 1995 POP plan and you'll get about 130 major 1995 IEEE conference proceedings — for \$11,995! This is the standard plan libraries have received for decades.

THE 1995 IEEE PREPAID ORDER PLAN PLUS (POP PLUS)

The 130 major conferences discussed above plus about 80 new 1995 IEEE conferences, workshops, and symposia in rapidly-emerging technologies — for \$16,975! POP Plus is all the 1995 IEEE conferences, in electrical engineering and computing in one plan.

SUBSCRIBERS TO BOTH PLANS RECEIVE:

- about a 38% savings off the total list prices of individual conferences
- a quarterly listing of the proceedings they should have received



THE INSTITUTE OF ELECTRICAL AND
ELECTRONICS ENGINEERS, INC.

To order or for more information, contact:

Robert S. Hohwald
(phone) 1-908-562-3999
(fax) 1-908-981-8062

(e-mail) INTERNET:r.hohwald@ieee.org

board of directors

James T. Cain, *President*
Phone: (908) 562-3928 Fax: (908) 981-9515
Internet: t.cain@ieee.org
Wallace S. Read, *President-Elect*
V. Thomas Rhyne, *Treasurer*
Charles W. Turner, *Secretary*
H. Troy Nagle, *Past President*
Theodore W. Hissey, Jr., *Executive Director*

Vice Presidents

Kenneth R. Laker, *Educational Activities*
Joel B. Snyder, *Professional Activities*
W. Kenneth Dawson, *Publication Activities*
Vijay K. Bhargava, *Regional Activities*
E.G. "Al" Keiner, *Standards Activities*
Bruce A. Eisenstein, *Technical Activities*

Division Directors

Suzanne R. Nagel (I) Stephen H. Unger (VI)
Pierre A. Thollot (II) John W. Pope (VII)
John S. Ryan (III) James H. Aylor (VIII)
Rolf H. Jansen (IV) John G. Ackenhusen (IX)
Gerald L. Engel (V) Tzyn-Jong (T.J.) Tarn (X)

Region Directors

Richard A. Ackley (1) William E. Murray (6)
Daniel R. Benigni (2) Raymond D. Findlay (7)
Deborah M. Powers (3) Peer Martin Larsen (8)
James R. Fancher (4) Hugo Fernandez Versteegen (9)
Ross C. Anderson (5) Paul Y.S. Cheung (10)

Donald G. Fink, *Director Emeritus*
Eric Herz, *Director Emeritus*

headquarters staff

Richard D. Schwartz, *acting General Manager*
Theodore W. Hissey, Jr., *Executive Director*

Staff Executives

Richard D. Schwartz, *Business Administration*
Phyllis Hall, *Publications*
Frank R. Moore, *Volunteer Activities*

Staff Directors

Irving Engelson, *Corporate Activities*
William Habingreither, *Customer Service*
Peter A. Lewis, *Educational Activities*
Melvin I. Olken, *Regional Activities*
Andrew G. Salem, *Standards Activities*
W. Thomas Suttle, *Professional Activities*
Robert Wangemann, *Technical Activities*

Staff Secretaries

Awards: Maureen Quinn
Board of Directors: Irving Engelson
Educational Activities: Peter A. Lewis
Regional Activities: Melvin I. Olken
Publishing: Phyllis Hall
Standards Activities: Andrew G. Salem
Technical Activities: Robert Wangemann
United States Activities: W. Thomas Suttle

For more information on Staff Secretaries to IEEE
Committees, please communicate with IEEE Corporate
Activities.

publications board

Lloyd A. Morley, *Chair*
Robert Dent, *Vice Chair*
Phyllis Hall, *Staff Secretary**

Frederick T. Andrews
Jonathan Dahl*
Bruce Eisenstein
Randall Geiger
William Middleton
William Perkins
G.P. Rodrigue
Allan Schell
Murray Slovick*
Patricia Walker*
George Watson*
Helen M. Wood

Deborah Cxyz*
Karsten E. Drangeid
Richard Fair
Dudley Kay*
Edmund Miller
Deborah M. Powers
Hugh Rudnick
True Seaborn*
Robert Volter
Robert Wangemann*
Peter Weisner*

*Ex officio

Publications Directors

Dudley Kay, *Director, IEEE Press*
Lewis Moore, *Director, Publications Administration*
Patricia Walker, *Director, Transactions/Journals*
Fran Zappulla, *Associate Publisher, Magazines/Newsletters*

editorial offices: New York City 212-705-7555 San Francisco 415-328-7570 Washington, DC 202-544-3790

EDITORIAL CORRESPONDENCE. *IEEE Spectrum*, 345 East 47th St., New York, NY 10017, Attn: Editorial Dept. Responsibility for the substance of articles published rests upon the authors, not the IEEE or its members. Letters to the editor may be excerpted for publication.

REPRINT PERMISSION. Libraries: Articles may be photocopied for private use of patrons. A per-copy fee (indicated after the code appearing at the bottom of the first page of each article) must be paid to the Copyright Clearance Center, 29 Congress St., Salem, MA 01970. Other copying or republication: Contact: Business Manager, *IEEE Spectrum*.

ADVERTISING CORRESPONDENCE. *IEEE Spectrum*, 345 East 47th

St., New York, NY 10017, Attention: Advertising Department, 212-705-7760. Also see Advertising Sales Offices listing on last page. The publisher reserves the right to reject any advertising. **COPYRIGHTS AND TRADEMARKS.** *IEEE Spectrum* is a registered trademark owned by The Institute of Electrical and Electronics Engineers, Inc. At issue, EE's tools & toys, EV watch, Faults & failures, Hardware Reviews, Innovations, Legal aspects, Managing technology, Newslog, Program notes, Reflections, Software Reviews, Speakout, Spectral lines, Spinoffs, Technically speaking, The engineer at large, Washington watch, and Whatever happened to? are trademarks of the IEEE.

GENERAL INQUIRIES: 1-800-678-IEEE; Corporate Office: 345

East 47th St., New York, NY 10017, 212-705-7900. Tel. Extensions: General Manager 7910.

Operations Center: Box 1331, 445 Hoes Lane, Piscataway, NJ 08855, 908-981-0060. Tel. Extensions: acting General Manager 5311, Educational Activities 5485, Membership Services U.S. 1-800-678-IEEE Non U.S. 1-900-981-0060, Ombudsman 6360, Corporate Communications 6822, Regional Activities 5501, Section Services 5515, Technical Activities 3900.

IEEE U.S.A. Office: 1828 L Street N.W., Suite 1202, Washington, DC 20036, 202-785-0017

coming in spectrum

Digital TV—some inside stories

This extensive *IEEE Spectrum* report brings together the people who have been hammering out a proposed U.S. standard for digital high-definition television (HDTV). Their first-hand accounts explain why that standard is being laid out the way it is. The companies involved include Philips Laboratories, Thomson Consumer Electronics, AT&T Bell Laboratories, General Instruments, and the David Sarnoff Research Center.

Other sections of the report will dissect interactive TV from the standpoint of the network and investigate design issues surrounding video servers and set-top boxes. Also discussed will be two standards, one for videotape in digital video recording, and the other for digital satellite TV, which was recently introduced in the United States.

Rounding out the world picture will be overviews of the status of advanced TV efforts in Europe and Japan.

Also, this issue will see the first of a new series entitled "Spectrum Visits." The first trip will be to see how technology

proposed for HDTV is put through its paces at the U.S. advanced TV committee's testing laboratory.

Focus Report: PCs and workstations

In its fifth annual report on engineering workstations and PCs, *Spectrum* breaks with the survey approach of the past and instead delves into the most important new aspects of desktop computing.

Readers will get a first look at one of the most significant developments in the technology of reduced-instruction-set computing (RISC): the hardware reference platform for the PowerPC, which is being jointly developed by Apple Computer, IBM, and Motorola.

A related story describes how one of the latest compilers was created in parallel with the design of the high-speed RISC chip it was destined to support. The intent was for the hardware and software engineering teams to optimize their wares to their own and each other's maximum advantage.

Wanted: EEs with children

Are you ecstatic over the way your kid decided to become an engineer after visiting your local science or technology museum? Or are you perhaps exasperated by the inaccuracy or boring nature of the EE-related exhibits?

Here's your chance to say what you—and the younger generation—think and why!

IEEE Spectrum is seeking engineers and their children willing to evaluate the quality and enjoyability of EE-related exhibits in major science and technology museums around the world. A summary of the evaluations of U.S. museums is scheduled to appear in the September 1995 *Spectrum* as the first of an occasional series on technology-related travel. Evaluations of museums in other nations will appear in later issues.

This project should (we hope) be fun as well as informative for both you and one or more local "test children"—be they your relations or a neighborhood buddy.

Intrigued? To receive further information on how to participate, please send your name, home address, telephone number, e-mail address, and names and ages of volunteer test children by **mail** to Trudy E. Bell, Senior Editor, *IEEE Spectrum*, 345 E. 47th St., New York, NY 10017, U.S.A.; by **fax** to 212-705-7453 or by **e-mail** to t.bell@ieee.org.

Please do NOT telephone the *Spectrum* offices!

advertising sales office

345 East 47th Street, New York, N. Y. 10017

Michael Triunfo	Advertising Manager	212-705-7312
Dawn Becker	Mid-Atlantic Manager	212-705-7311
Eric Sonntag	Sales Promotion Manager	212-705-7017
Theresa Fitzpatrick	Assoc. Promotion Manager	212-705-7579
Martin Barbieri	Advertising Production Manager	908-562-6334

New Jersey—Alan Pearce,
National Consumer Advertising Manager
368 Essex Street, Millburn, NJ, 07041 201-467-8121

Boston, MA—Doug Long,
46 Main St., P.O. Box 2780, Orleans, 02653 508-255-4014

Chicago, IL—Ralph Bergen,
One Northfield Plaza, Suite 300, Northfield, 60093 708-446-1444

San Francisco, CA—Denis F. Duffy,
3755 Balboa Street, Suite 201, 94121 415-386-5202

Los Angeles, CA—Lynne Andrew Evans,
5757 West Century Boulevard, #700, 90045 310-649-3800

Atlanta, GA—H. Michael Coleman, C. William Bentz III,
4651 Roswell Road N.E., Suite #F503, 30342 404-256-3800

Denver, CO—David B. Schissler,
32570 Aspen Meadow Drive, Evergreen, 80439 303-670-3749

Dallas, TX—Matt Kincaid, Eric Kincaid,
9794 Forest Lane, Suite 634, 75243 214-553-9896

Tokyo, Japan—German Tajiri,
IMI Corp., Saito Lend Bldg., 13-5, Ginza 3-chome, Chuo-ku,
Tokyo 104. (03) 3546-2231. TELEX: J23449 (IMI TOKYO)

Munich, Germany—Ric Bessford, Leopoldstr. 52,
80802 Munich 40, Germany, 49-89-39-00-55

Surrey, England—John F. Gold, 16 Woodside Road,
Sutton, Surrey SM1 3SU, Tel/Fax: 44 (0)81 641 7717

Associate Publishers: William R. Saunders (Advertising);
Murray Slovick (Editorial); Fran Zappulla (Operations)

Administrative Assistants: Nancy T. Hantman, Christine Demchak

advertisers index

Circle numbers on the Reader Service Card, opposite page 69, that correspond to the advertisers listed below. *Advertiser in North American edition. **Advertiser in North American Exact edition.

RS#	Advertiser	Page #
63	AES	73
1	Alacron	7
5	American Power Conversion	12
3	Ansoft	Cover 3
	CACI	Cover 2
4	Comsat Laboratories	71
32	*Cool AMP Conducto Lube	18T2
56	DEH Printed Circuits	72
6	DSP Development	13
24	Gage Applied Sciences	82
58	Harmonic Software	73
7	Hewlett-Packard PMO	5
	**IEEE Financial Advantage Program	16E7
	**IEEE Financial Advantage Program	16E3
25	**InfoNow	16E5
2	Integrated Systems	11
26	**Interkama	16E2
51	Intusoft	72
27	**Kaman Instrumentation	16E6
9	MacNeal-Schwendler MSC/EMC	10
36	*Macysma	18T4
10	MathWorks	Cover 4
11	MathWorks	9
	Microsoft	21
12	Mita Press	12
13	National Instruments	8
14	National Instruments	14
52	National Instruments	72
	NEC	42/3
61	Pioneer Hill Software	73
29	**Powerex	16E4
35	*Research Systems	18T6
30	**Research Systems	16E8
15	Safe Engineering Services & Technologies	71
33/34	**SciTech International	68E8
21	Scitor	3
	*Seabury & Smith Insurance	18T1
28	*Software Publishing	18T3
16	Statistical Sciences	23
20	Structural Research & Analysis	16
53	Tal Enterprises	72
31	**TRW/SIG	16E1
57	Ultratrust International	73
54	Ultraview	72
59	Western Design Center	73
17	Wolfram Research	15
64	Z-World Engineering	73

NEW! Tap into this billion-dollar wireless market...

WIRELESS PERSONAL COMMUNICATIONS

The Future of Talk

By Ron Schneiderman, Sr. Editor,
Microwaves and RF Magazine
and *Microwaves and RF Product Extra*

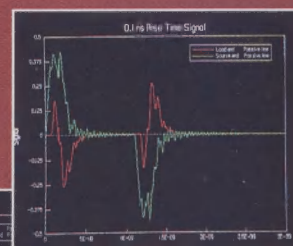
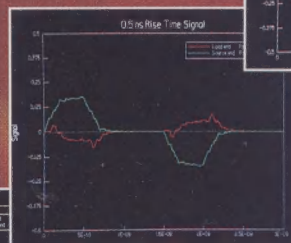
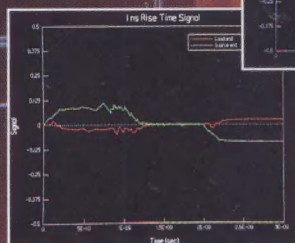
In this comprehensive book you will find a complete overview of the wireless market including emerging technologies, regulatory issues, standards, competitive analysis, market projections and opportunities overseas. Key topics covered include cellular/personal communications, mobile satellite services, wireless messaging, portable computing and wireless LANs/PBXs. Included is a directory of over 150 companies, trade associations and government and regulatory agencies involved in wireless activities.

\$29.95 (\$25.00 member)
1994 Hardcover 224 pp
IEEE Order No. PC3590
ISBN: 0-7803-1010-1



For fastest service, call
1-800-678-IEEE
(1-908-981-0060 outside the U.S.)
or fax: 1-908-981-9667

SIGNAL INTEGRITY HEADACHES?



Crosstalk increases dramatically as signal speeds rise.

Courtesy of Motorola, Austin

Crosstalk – Ground bounce – Parasitics – REFLECTIONS!
As designs get faster, the headache only gets worse.

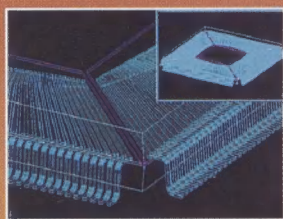
calculations, or 2D transmission line or planar simulators for simpler structures.

1 Proven 3D Extraction

Your designs include packaging, power and ground planes, and multi-layer components – all complicated 3D structures. And nobody does 3D like Ansoft. The 3D field solvers in Maxwell® Spicelink are built on decades of engineering experience and guaranteed correct, accurate answers.

2 Inductance & Non-Ideal Grounds

At clock speeds above 50MHz, inductive effects – such as "ground bounce" – can cripple board, MCM, and package designs. Maxwell offers a proven method of characterizing non-ideal grounds and loop inductance – not partial inductance – so that you KNOW what is happening in your design.



Courtesy of NCR Microelectronics

**Ansoft
has
the
cure.**

4 SPICE-Level Accuracy

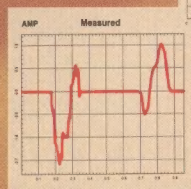
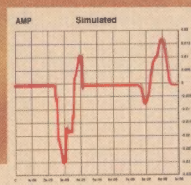
Maxwell Spicelink combines SPICE-level accuracy with accelerated run times on interconnect models. Built-in accelerator for commercial SPICE allows interconnect to be modeled in existing SPICE environments.



Courtesy of AMP Interconnect Systems

5 Experience

Developing genuine cures for signal integrity problems is not easy – others have tried. Join the hundreds of engineers already using our tools to cure their design headaches.



Call for a brochure on Maxwell Spicelink: the signal integrity cure. Or you can take two aspirin...again.

3 Choice of Extraction Methods

Maxwell gives you all the extraction you need in a single program. Use our fast finite element technology for resistance and inductance calculations, multipole accelerated boundary elements for capacitance

Circle No. 3



Ansoft Corporation
Four Station Square Suite 660
Pittsburgh, PA 15219 USA
Telephone: 412-261-3200
Fax: 412-471-9427
Internet: info@ansoft.com

The companies and products named are trademarks of their manufacturers.

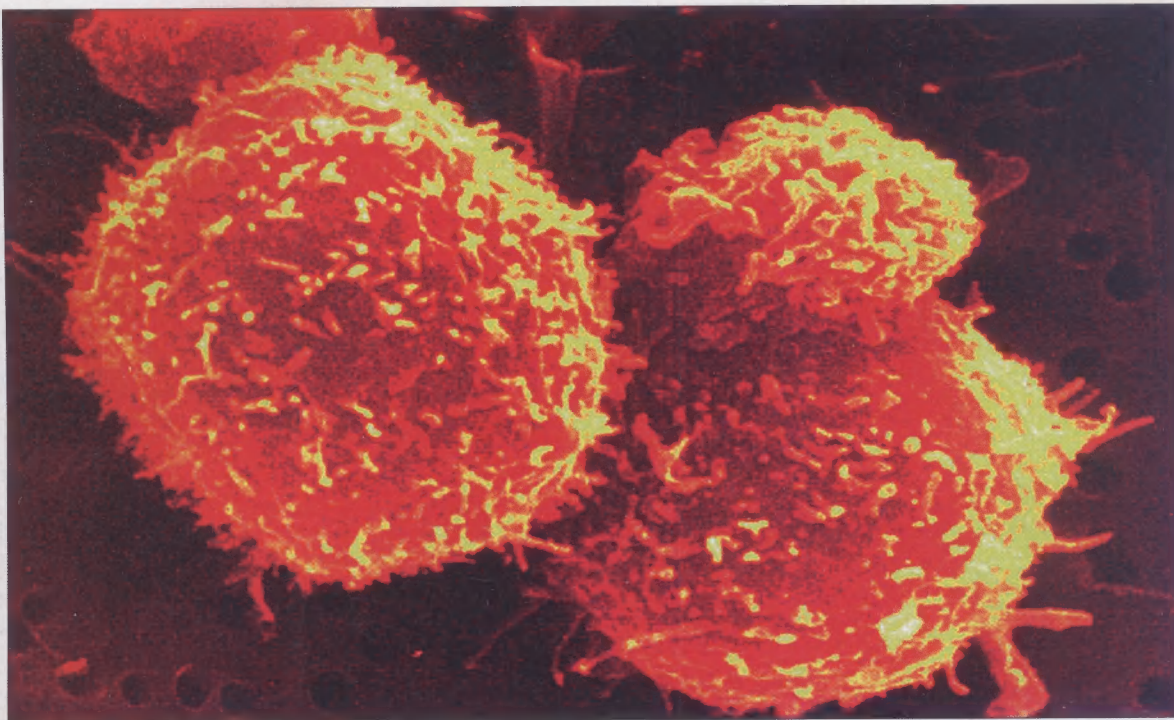


Image from a scanning electron microscope, rendered and enhanced with MATLAB. Nonlinear contrast adjustment emphasizes object details.

See beyond the limits of ordinary image processing—with MATLAB.[®]

The Image Processing Toolbox is the latest addition to the MATLAB Technical Computing Environment. In the world's most powerful system for numeric matrix computation, an image is simply a matrix. That's why you can take image processing further with MATLAB.

Open doors to advanced image processing

The MATLAB Image Processing Toolbox gives you an unrivaled ability to visualize, manipulate, and analyze images and two-dimensional signals. It's easy to explore, apply, and create the innovative image processing methods that let you keep up with—and advance—the leading edge.

Break through the barriers

Until now, all image processing packages have fallen short when it comes to crunching the numbers behind the images.

The Image Processing Toolbox is different. It gives you all the tools you need, in the interactive MATLAB environment. You can

easily treat image data visually or numerically. And since you never have to scale data or juggle multiple packages, you get accurate results immediately.

Build on a solid foundation

In MATLAB, you can easily modify any function or add custom tools without writing a single line of Fortran or C code.

You can also create portable GUI applications that look and feel like pre-packaged software, but address specific end-user problems.

Free your imagination

Image processing technology has become essential to scientific and engineering work. And now, within the MATLAB environment, you can easily integrate image processing with powerful computational techniques such as statistics, optimization, and neural networks. Move beyond the limits of ordinary image processing packages—with MATLAB.

Image Processing Toolbox

- Image and feature enhancement
- Image restoration and filtering
- Linear and nonlinear filter design
- Image analysis and 2-D transforms
- Color, geometric, and morphological operations
- Color, grayscale, and binary images and sequences
- Imports/exports standard image formats
- Runs on PCs, Macs, and workstations

To order, or for more information, call
508-653-1415

The
**MATH
WORKS**
Inc.

24 Prime Park Way
Natick, MA 01760-1500
Fax: 508/653-6284
Email: info@mathworks.com
Web: <http://www.mathworks.com>

MATLAB is a registered trademark of The MathWorks, Inc.

The MathWorks is represented in the following countries: Australia: +61-2-922-6311 • Brazil: +55-11-816-3144 • France: +33-1-45-34-23-91 • Germany: +49-241-26041 • India: +91-80-2-260-260 • Israel: +972-3-561-5151 • Italy: +39-11-24-85-332 • Japan: +81-3-5978-5410 • Korea: +82-2-517-1257 • Portugal: +34-3-415-49-04 • Scandinavia: +46-8-15-30-22 • Spain: +34-3-415-49-04 • Switzerland: +41-31-998-44-11 • Taiwan: +886-2-501-8787 • For Belgium, Luxembourg, The Netherlands, United Kingdom and Republic of Ireland call Cambridge Control, Ltd: +44-1223-423-200 or Rapid Data, Ltd: +44-903-821-266